Modbus IO
User Manual
Version 2.0, Revision A

IO Slave (board-level)
FGRIO-S
FGR2-IOS-C-U
I2-IOS-C-U

IO Slave (enclosed)
FGR2-IOS-CE-U

IO Expansion Radio Base
FGR2-IO-IOE

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UL Notification:

Models FGR2-IOS-C-U, FGR2-IOS-CE-U, FGR2-IO-IOE, and I2-IOS-C-U are suitable for use in Class I, Division 2, Groups A, B, C, and D or non-hazardous locations only. Input voltage for the above models is 6 – 30 V DC

Warning—Explosion Hazard—Substitution of components may impair suitability for Class I, Division 2.

The diagnostics port and cable do not have a latching connector and cannot be used in a hazardous location.

Model FGRIO-S is suitable for use in Class I, Division 2, Groups A, B, C, and D or non-hazardous locations only. Input voltage for the above model is 6 – 20 V DC

Warning—Explosion Hazard—Substitution of components may impair suitability for Class I, Division 2.

The diagnostics port and cable do not have a latching connector and cannot be used in a hazardous location.

Safety Information:

Do not exceed the maximum ratings for the product.

These products can fail in a variety of modes due to misuse, age, or malfunction. Systems with these products must be designed to prevent personal injury and property damage during product operation and in the event of product failure.

The described systems are based on wireless Radio Frequency (RF) technologies. RF is subject to interference and communication interruptions. It should not be expected, therefore, to provide 100% communication 100% of the time. The described systems should not be used without proper provisions to ensure safe operation upon loss of radio communications.

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Equipment Requirements

1. Firmware requirements:
   - FGRO9CSU, FGR-115RC, FGR-115WC Serial Master: firmware version 2.44 or greater
   - FGR2-C-U, FGR2-CE-U Serial Master: Any firmware version
   - IM-500X007, IM-800X009, IM-900X009: firmware version 3.44 or higher
   - I2-C-U, I2-CE: Any firmware version
   - FGRIO-S: firmware version 2.64IO or greater
   - FGR2-IOS-C-U, FGR2-IOS-CE-U, FGR2-IO-IOE, I2-IOS-C-U: Any firmware version
2. Any FGR, FGR2, IM, or I2 serial radios are to be installed as the Multipoint Master and Repeater(s) (if required). FGRIO-S, FGR2-IOS-C-U, FGR2-IOS-CE-U, FGR2-IO-IOE, and I2-IOS-C-U radios are to be installed as a Multipoint Slave.
3. Modbus IO **WILL NOT** work with DGR series radios.

Decreased Capabilities

Table 1 shows the decreased product capabilities for specific products as of March 18th, 2011:

Table 1. Summary of decreased capabilities by product.

Product	Capability	Specification	Actual
I2-IOS-C-U	Analog input accuracy	+/- 0.1%	+/- 0.5%

Setup:

The following are the system setup requirements.
NOTE: This document is written from the perspective of both Hyper Terminal and Tool Suite.

Terminology:

Modbus IO Slave – Any of the radio models FGRIO-S, FGR2-IOS-C-U, FGR2-IOS-CE-U, I2-IOS-C-U, or FGR2-IO-IOE

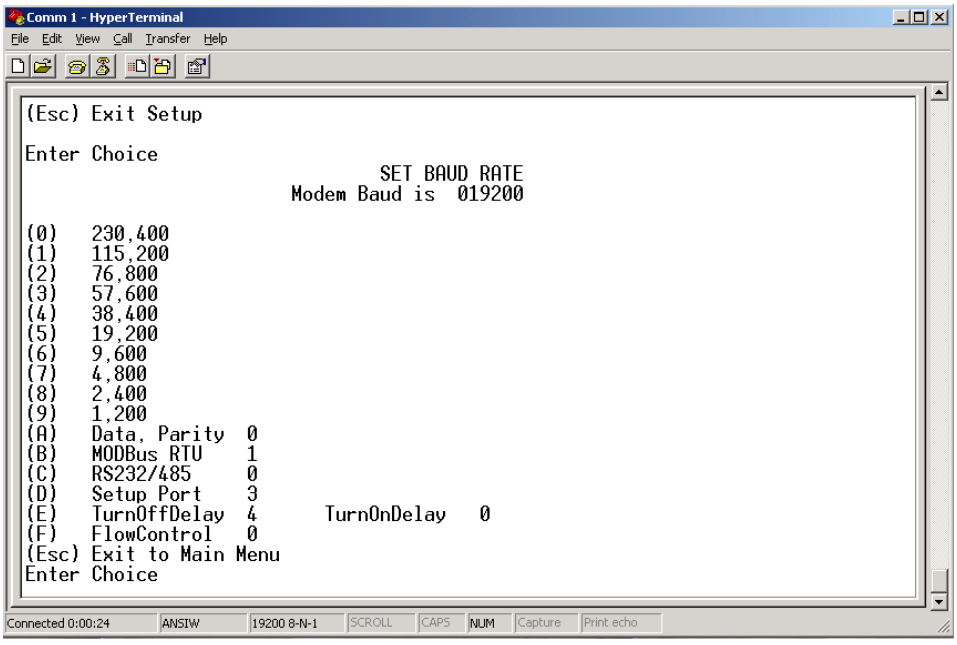
Serial Master – Any FGRO9CSU, FGR-115RC, FGR2-C-U, FGR2-CE-U, IM-500X007, IM-800X009, IM-900X009, I2-C-U, or I2-CE radio configured as the Multipoint Master.

Terminal Window Setup:

Below are the instructions from the Perspective of a Terminal window:

Serial Master Setup

1) The Serial Master must be set as follows:
    a. Menu **(0) Set Operation Mode**
        i. Set the Serial Master to **(2) Point to MultiPoint Master**.
    b. Menu **(1) Set Baud Rate**
        i. Set the Baud Rate (0 – 9) to match the polling host connected to the Serial Master's serial port.
        ii. Set **(B) Modbus RTU** to 1

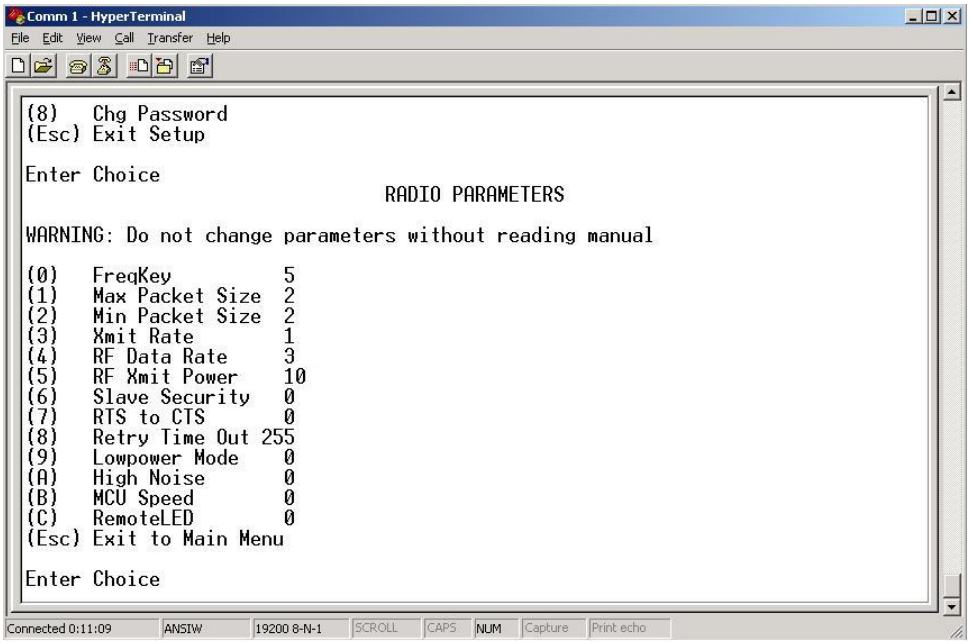


FGR Master Menu 1

    c. Menu **(2) Edit Call Book**
        i. Not recommended. It is recommended to use **Network ID** (see p. 7) rather than the Call Book.

d. Menu **(3) Edit Radio Transmission Characteristics**

i. Set **(0) FreqKey** as necessary.

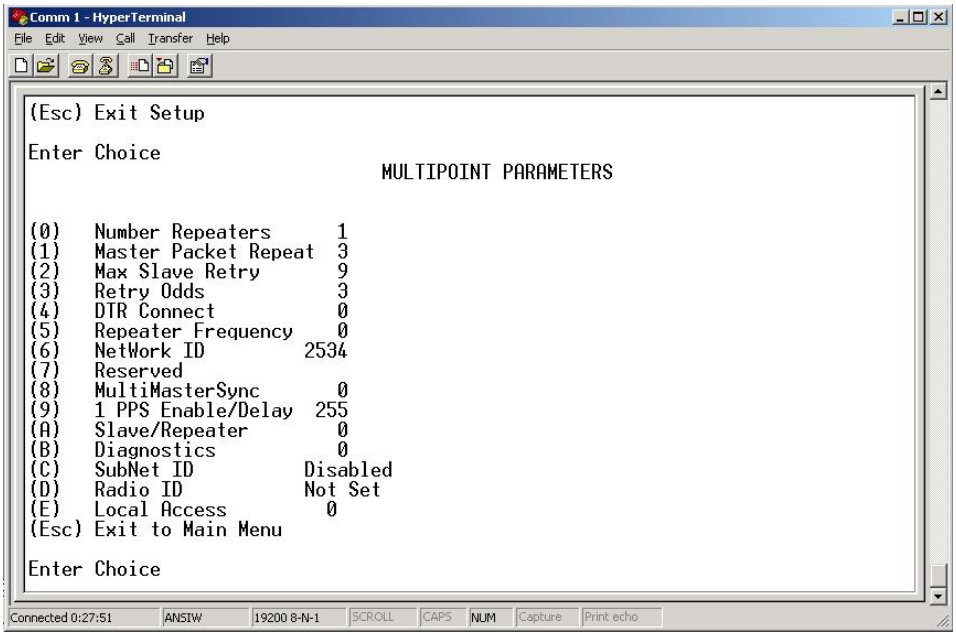


Menu (3) Edit Radio Transmission Characteristics

ii. Set **(1) Max Packet Size** and **(2) Min Packet Size** to match the Modbus IO Slave

NOTE: 2 and 2 are the smallest Max and Min Packet sizes that can be used for Modbus IO Systems.

1. A **Max Packet Size** setting of 2 and **Min Packet Size** setting of 2 is also the recommended packet sizing, as it should handle most Modbus packets with the best throughput.
2. There is a relationship between packet size and maximum reliable counting rate of the DI counters. With Max = 2, Min = 2 packet sizes, up to 1000 Hz (at 50% duty cycle, 500uSec per phase) can be counted.
3. The Modbus IO System will function with larger packet sizes, but count rate will be reduced; sizes of Max = 9, Min = 9 will reliably count to 10 Hz (50msec per phase).
4. Modbus IO Systems using packet sizes of 2 and 2 will typically draw more current than if the systems were programmed to use larger packet sizes.
5. Other settings in menu 3 are to be set at the users' discretion according to the FreeWave User Manual.

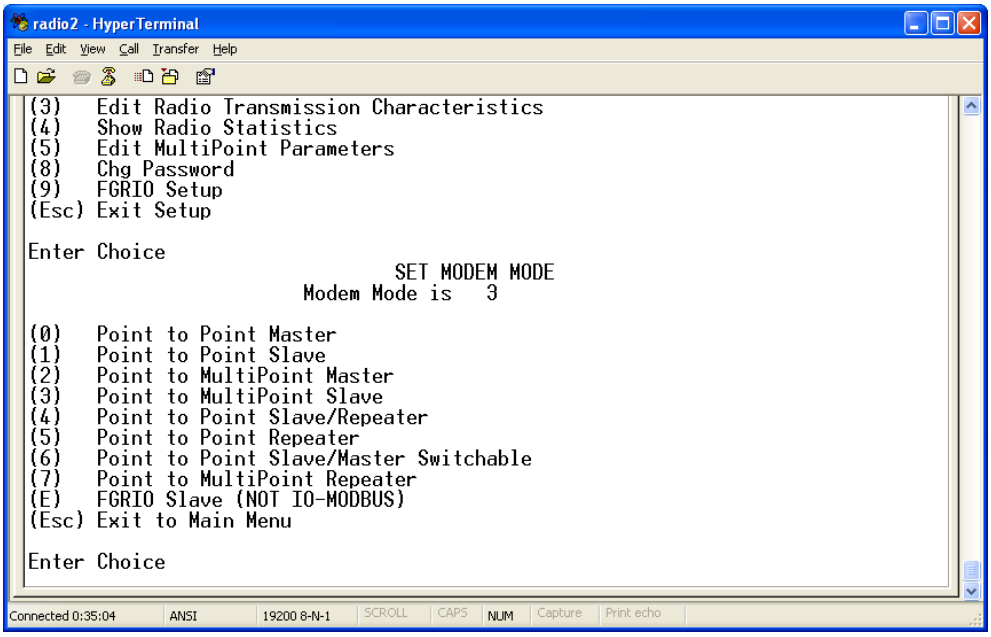


FGR Master Menu 5

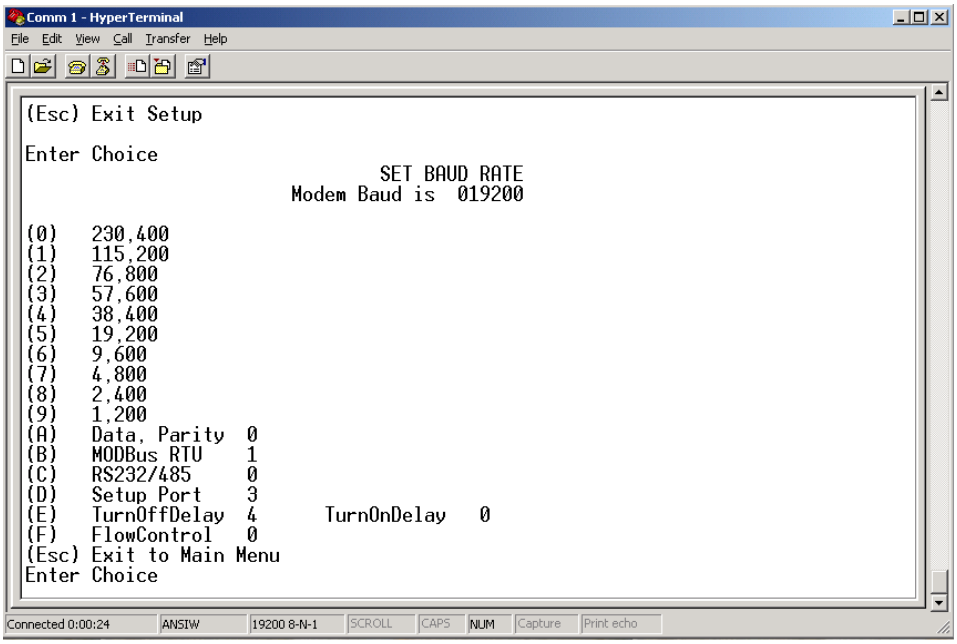
e. Menu **(5) Edit Multipoint Parameters**
   i. Set **(0) Number Repeaters** to 0 if there are no Repeaters in the network or 1 if there are 1 or more Repeaters in the network.
   ii. Set **(1) Master Packet Repeat** according to network interference conditions and message reliability requirements. A setting of 2 or greater is recommended.
   iii. Set **(6) Network ID** to a unique value from 0 to 4095. (Do not use 255, since using this number would enable the CallBook [Menu 2]).
   iv. Other settings in menu 5 are to be set at the users' discretion according to the FreeWave User Manual.

Modbus IO Slave Setup

2) The Modbus IO Slave must be set as follows:
   a. Menu **(0) Set Operation Mode** – set the Modbus IO Slave to **(3) Point to MultiPoint Slave**.
      i. DO NOT SET TO (E) FGRIO SLAVE


radio2 - HyperTerminal
File Edit View Call Transfer Help
(3) Edit Radio Transmission Characteristics
(4) Show Radio Statistics
(5) Edit MultiPoint Parameters
(8) Chg Password
(9) FGRIO Setup
(Esc) Exit Setup
Enter Choice
SET MODEM MODE
Modem Mode is 3
(0) Point to Point Master
(1) Point to Point Slave
(2) Point to MultiPoint Master
(3) Point to MultiPoint Slave
(4) Point to Point Slave/Repeater
(5) Point to Point Repeater
(6) Point to Point Slave/Master Switchable
(7) Point to MultiPoint Repeater
(E) FGRIO Slave (NOT IO-MODBUS)
(Esc) Exit to Main Menu
Enter Choice
Connected 0:35:04 ANSI 19200 8-N-1 SCROLL CAPS NUM Capture Print echo
Modbus IO Slave Menu 0

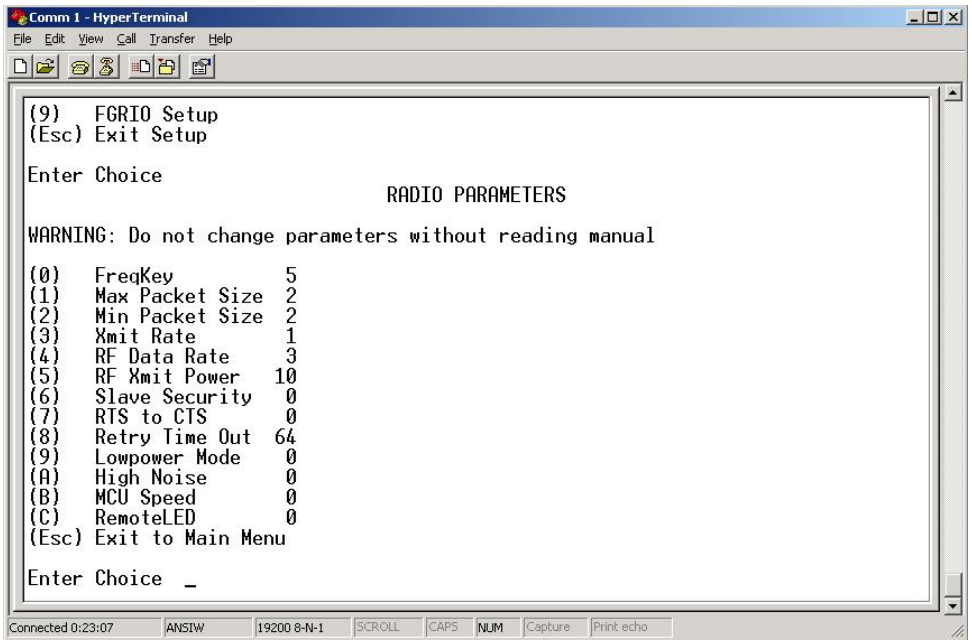
b. Menu **(1) Set Baud Rate**
   i. Set **(B) Modbus RTU** to 1.
   ii. If a serial device will be connected to the Modbus IO Slave's serial port, the radio's baud rate (Options **0 – 9**) should match the baud rate of the connected device.



Modbus IO Slave Menu 1

c. Menu **(2) Edit Call Book**
   i. Not recommended. It is recommended to use **Network ID** (see p.8) rather than the Call Book.

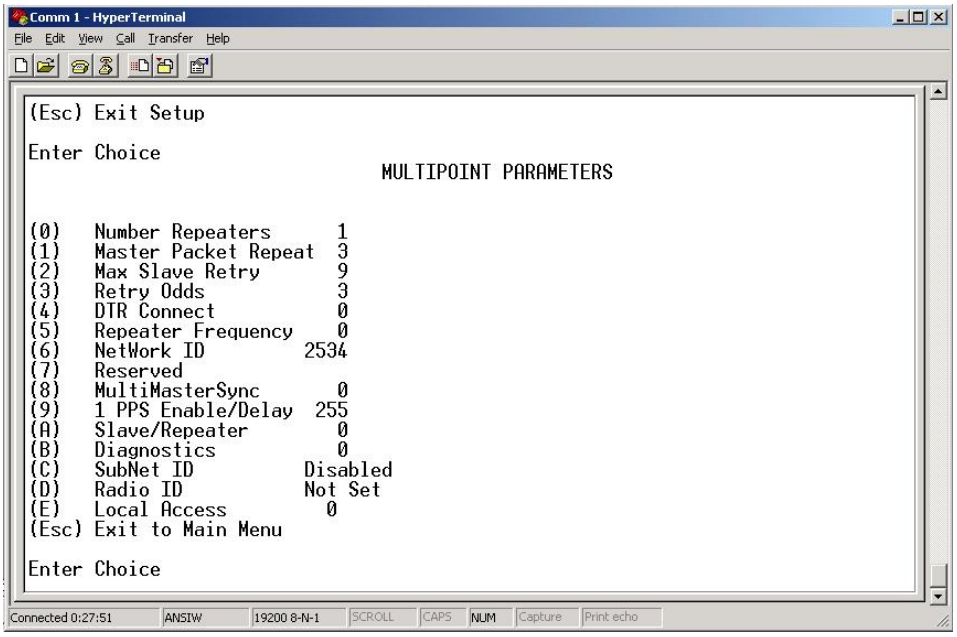
d. Menu **(3) Edit Radio Transmission Characteristics**
   i. Set **(0) FreqKey** as necessary to match the Serial Master or Repeater.



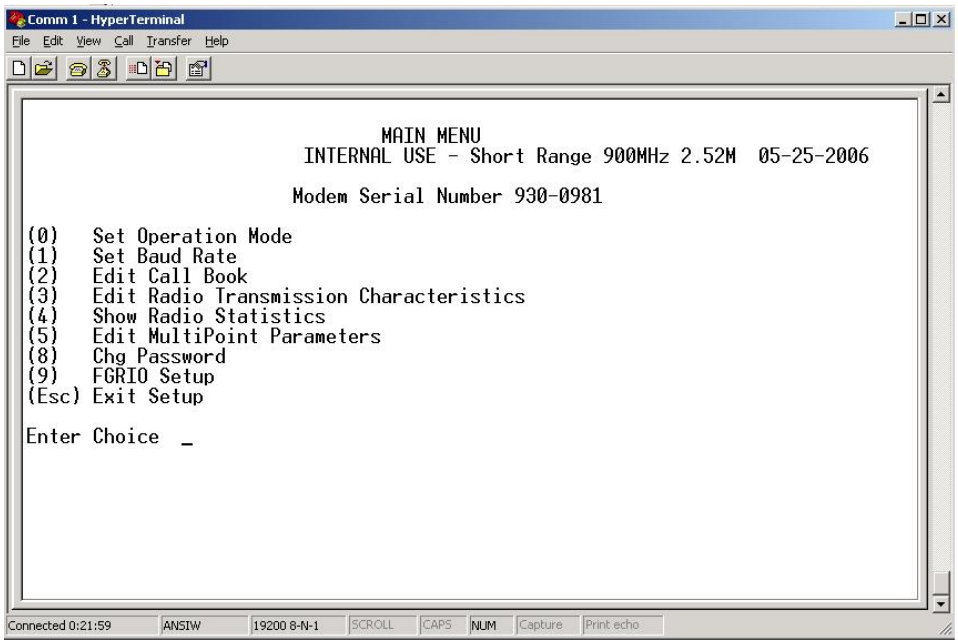
Modbus IO Slave Menu 3

   ii. Set **(1) Max Packet Size** and **(2) Min Packet Size** to match the Serial Master.
   iii. Set Retry Time Out; greater than or equal to 64 is recommended.
   iv. Other settings in Menu **(3)** are to be set at the users' discretion according to the FreeWave User Manual.

e. Menu **(5) Edit Multipoint Parameters**
   i. Set **(1) Master Packet Repeat** to match the Modbus Network Master.
   ii. Set **(6) Network ID** to match the Modbus Network Master.
   iii. Other settings in menu **(5)** are to be set at the users' discretion according to the FreeWave User Manual.

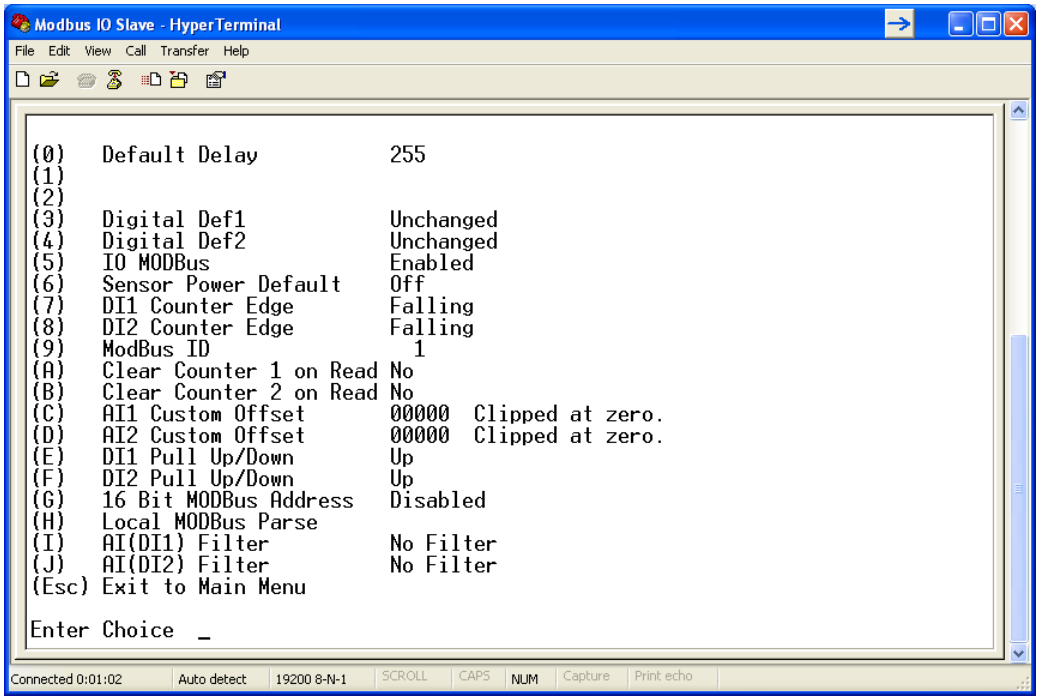

Comm 1 - HyperTerminal
File Edit View Call Transfer Help
(Esc) Exit Setup
Enter Choice
MULTIPOINT PARAMETERS
(0) Number Repeaters 1
(1) Master Packet Repeat 3
(2) Max Slave Retry 9
(3) Retry Odds 3
(4) DTR Connect 0
(5) Repeater Frequency 0
(6) NetWork ID 2534
(7) Reserved
(8) MultiMasterSync 0
(9) 1 PPS Enable/Delay 255
(A) Slave/Repeater 0
(B) Diagnostics 0
(C) SubNet ID Disabled
(D) Radio ID Not Set
(E) Local Access 0
(Esc) Exit to Main Menu
Enter Choice
Connected 0:27:51 ANSIW 19200 8-N-1 SCROLL CAPS NUM Capture Print echo

Modbus IO Slave Menu 5


Comm 1 - HyperTerminal
File Edit View Call Transfer Help
MAIN MENU
INTERNAL USE - Short Range 900MHz 2.52M 05-25-2006
Modem Serial Number 930-0981
(0) Set Operation Mode
(1) Set Baud Rate
(2) Edit Call Book
(3) Edit Radio Transmission Characteristics
(4) Show Radio Statistics
(5) Edit MultiPoint Parameters
(8) Chg Password
(9) FGRIO Setup
(Esc) Exit Setup
Enter Choice _
Connected 0:21:59 ANSIW 19200 8-N-1 SCROLL CAPS NUM Capture Print echo

Modbus IO Slave Main Menu

f. Menu **(9) FGRIO Setup**
   i. When **(9) FGRIO Setup** is selected and option **(5) IO MODBus** is set to Enabled, the menu below will appear.


Modbus IO Slave - HyperTerminal
File Edit View Call Transfer Help
(0) Default Delay 255
(1)
(2)
(3) Digital Def1 Unchanged
(4) Digital Def2 Unchanged
(5) IO MODBus Enabled
(6) Sensor Power Default Off
(7) DI1 Counter Edge Falling
(8) DI2 Counter Edge Falling
(9) ModBus ID 1
(A) Clear Counter 1 on Read No
(B) Clear Counter 2 on Read No
(C) AI1 Custom Offset 00000 Clipped at zero.
(D) AI2 Custom Offset 00000 Clipped at zero.
(E) DI1 Pull Up/Down Up
(F) DI2 Pull Up/Down Up
(G) 16 Bit MODBus Address Disabled
(H) Local MODBus Parse
(I) AI(DI1) Filter No Filter
(J) AI(DI2) Filter No Filter
(Esc) Exit to Main Menu
Enter Choice _
Connected 0:01:02 Auto detect 19200 8-N-1 SCROLL CAPS NUM Capture Print echo

Modbus IO Slave (Board level) Menu 9

(9) FGRIO Setup Menu Descriptions

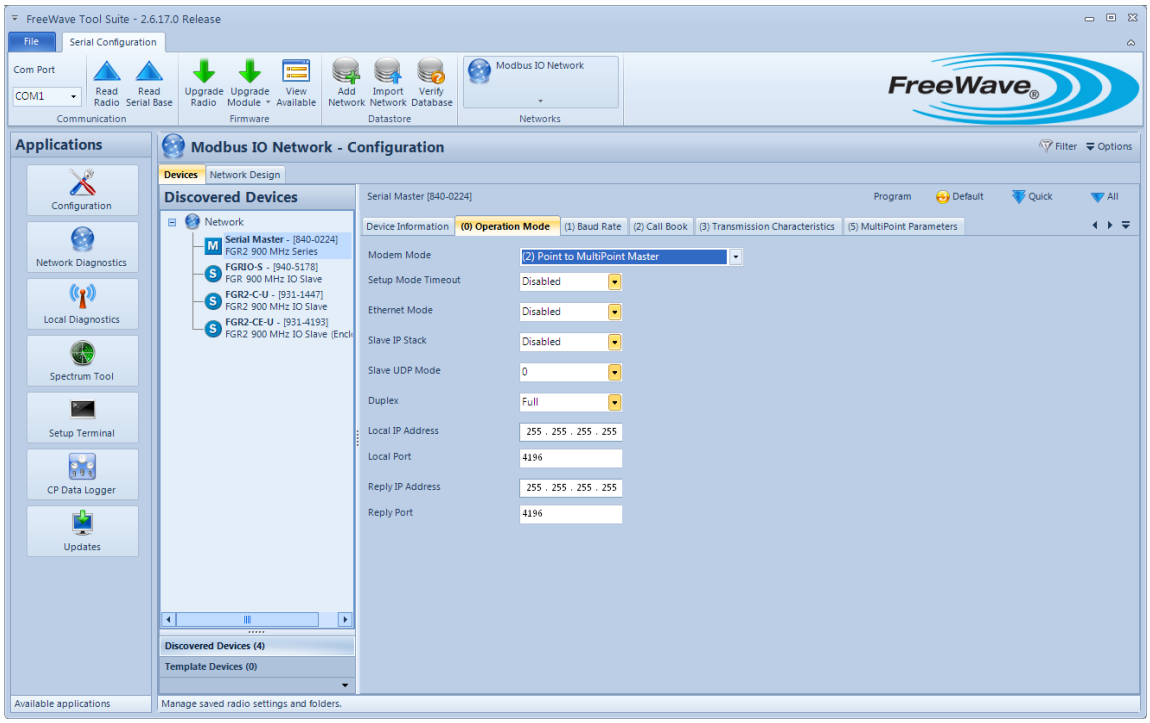
Option	Function Description	Available in Models
(0) Default Delay	This setting configures the time the radio will wait, after a loss of communication with the Serial Master or Repeater, before the radio enters default condition. This value is in .28 second intervals. e.g. A value of 36 = 36*0.28 sec. = 10.08 sec.	All Modbus IO Slave models
(1)	Not Used	
(2)	Not Used	
(3) Digital Def1 (4) Digital Def2	Controls the state of the digital output defaults invoked on loss of communication. See option **(0) Default Delay**, described above, for timing. **(0) On** - energized (Contact to GND is closed) **(1) Off** - not energized (Contact is open) **(2) Unchanged** - if communication is lost, do not change state.	All Modbus IO Slave models
(5) IO MODBus	Will show IO Modbus as either **Enabled** or **Disabled**. Press 5 to toggle the function. The screen shot above shows the menu with Modbus enabled.	All Modbus IO Slave models
(6) Sensor Power Default	Toggles the state of the Sensor Power pin on power-up. **On** - Connected to source voltage **Off** - Open Contact	All Modbus IO Slave models

(7) DI1 Counter Edge (8) DI2 Counter Edge	DI1 and DI2 Counter Edge, toggles between Rising and Falling edge.	All Modbus IO Slave models
(9) ModBus ID	Modbus ID is a user -selectable value from 1– 246, or, with **(G) 16 Bit Addressing** Enabled, 1-65535. Each Modbus IO Slave radio acting as a Modbus device will require a unique Modbus ID.	All Modbus IO Slave models
(A) Clear Counter 1 on Read (B) Clear Counter 2 on Read	Clear Counter (1 or 2) on Read, if set to 'Yes', will clear the count on the given DI immediately after Read. This prevents loss of counts which could occur between a Read operation and a later Clear operation. NOTE: Clear on Read only works when both 16 bit registers are read together in a single Modbus poll.	All Modbus IO Slave models
(C) AI1 Custom Offset (D) AI2 Custom Offset	User-entered values to subtract from the AI1 and AI2 MSW (Most Significant Word) measurements to provide zero-shifted versions of AI1 and AI2. The results can be either clipped at zero or allowed to wrap to full scale. See the Register Map for further information.	All Modbus IO Slave models
(E) DI1 Pull Up/Down (F) DI2 Pull Up/Down	Controls the power-up states of the internal resistor (10 KΩ) connected to the DIs. • **(0) Down:** The 10 KΩ internal resistor attached to the input is connected to GND to provide a pulldown for closed-contact-to-voltage sensors. • **(1) Up:** The 10 KΩ internal resistor attached to the input is connected to the 3.3V logic supply to provide a pullup for closed-contact-to-GND sensors. • **(2) None:** The internal resistor is not connected, allowing the connected sensor to provide > 1.75V DC for high and <1.75V DC for low.	All Modbus IO Slave models
(G) 16 Bit Modbus Address	Toggles between **Disabled** (8-bit addressing) and **Enabled** (16-bit addressing)	All Modbus IO Slave models
(H) Local Modbus Parse	This option is used for FreeWave Tool Suite Application Support	All Modbus IO Slave models
AI(DI1) and AI(DI2)Filter	Toggles between filtered (reading an analog signal on DI1 or 2) and Non Filtered (reading a Digital signal on DI1 or DI2).	

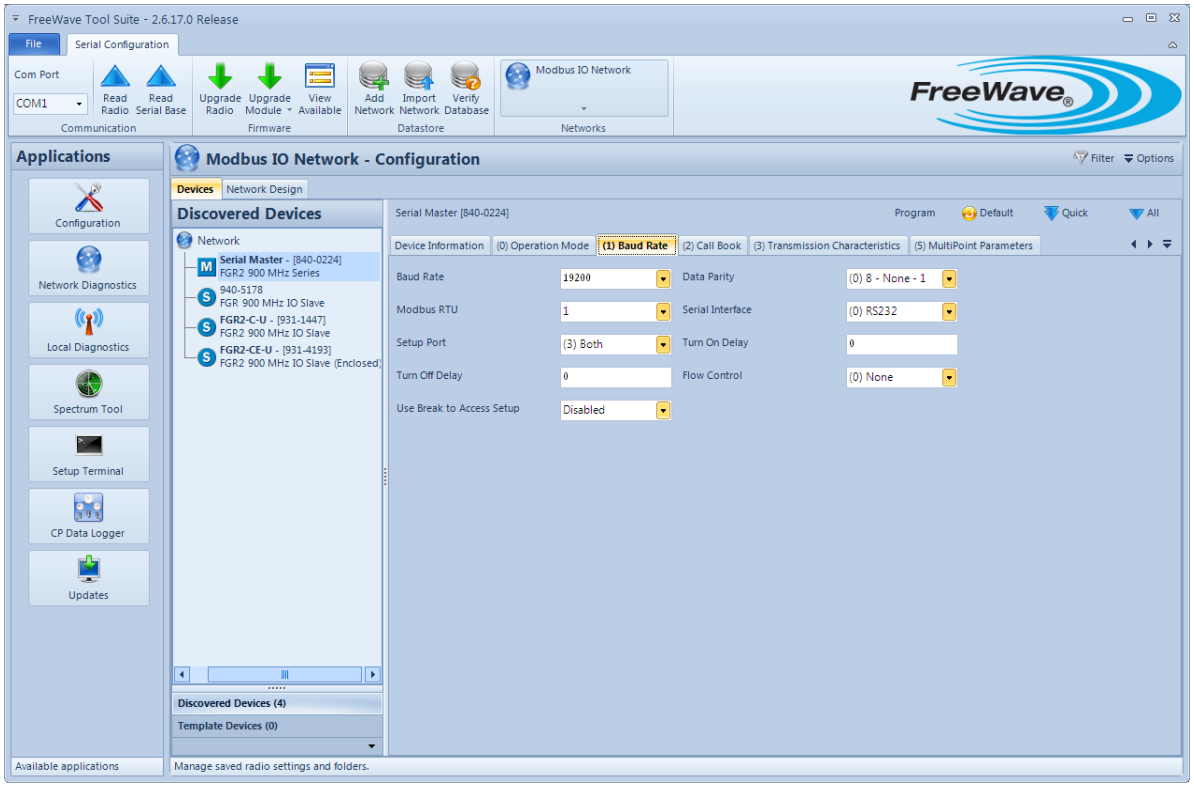
FreeWave Tool Suite Setup

Serial Master Setup

3) Configuring the Serial Master:
   - **a. (0) Operation Mode** Tab
     - i. The Serial Master Must be set to **(2) Point to MultiPoint Master**.
     - ii. Additional settings of the **Operation Mode** tab should be left at the factory default of off.



   - **b. (1) Baud Rate** Tab
     - i. Select the appropriate **Baud Rate** and **Data Parity** to connect the polling host to the radio.
     - ii. **Modbus RTU** MUST be set to **1**.
     - iii. Additional settings to be set per the FreeWave Spread Spectrum User Manual.



c. (2) Call Book Tab

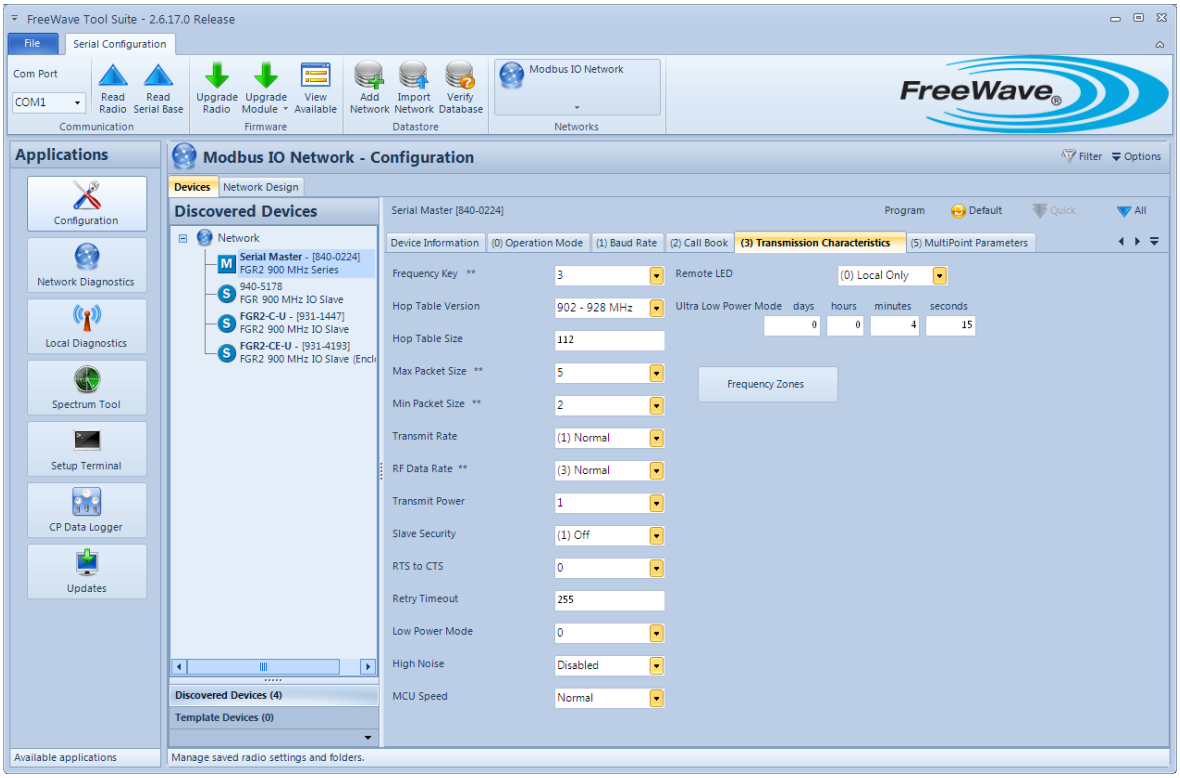
i. The call book tab is not used in the Modbus IO application.

d. (3) Transmission Characteristics Tab

i. A **Max Packet size** setting of **2** and **Min Packet size** setting of **2** is the recommended packet sizing, as it should handle most Modbus packets with the best throughput.

1. There is a relationship between packet size and maximum reliable counting rate of the DI counters. With 2, 2 packet sizes, up to 1000 Hz (at 50% duty cycle, 500uSec per phase) can be counted.
2. The Modbus IO System will function with larger packet sizes, but count rate will be reduced; sizes of 9, 9 will reliably count to 10 Hz (50msec per phase).
3. Modbus IO Systems using packet sizes of 2 and 2 will typically draw more current than if the systems were programmed to use larger packet sizes.

ii. Other settings on the **Transmission Characteristics** tab are to be set at the users' discretion according to the FreeWave User Manual.



e. (5) MultiPoint Parameters Tab

i. Set **Repeaters** to **Off** if there are no Repeaters in the network or **On** if there are 1 or more Repeaters in the network.

ii. Set **Master Packet Repeat** according to network interference conditions and message reliability requirements. A setting of **2** or greater is recommended.

iii. Set **Network ID** to a unique value from **0** to **4095**.

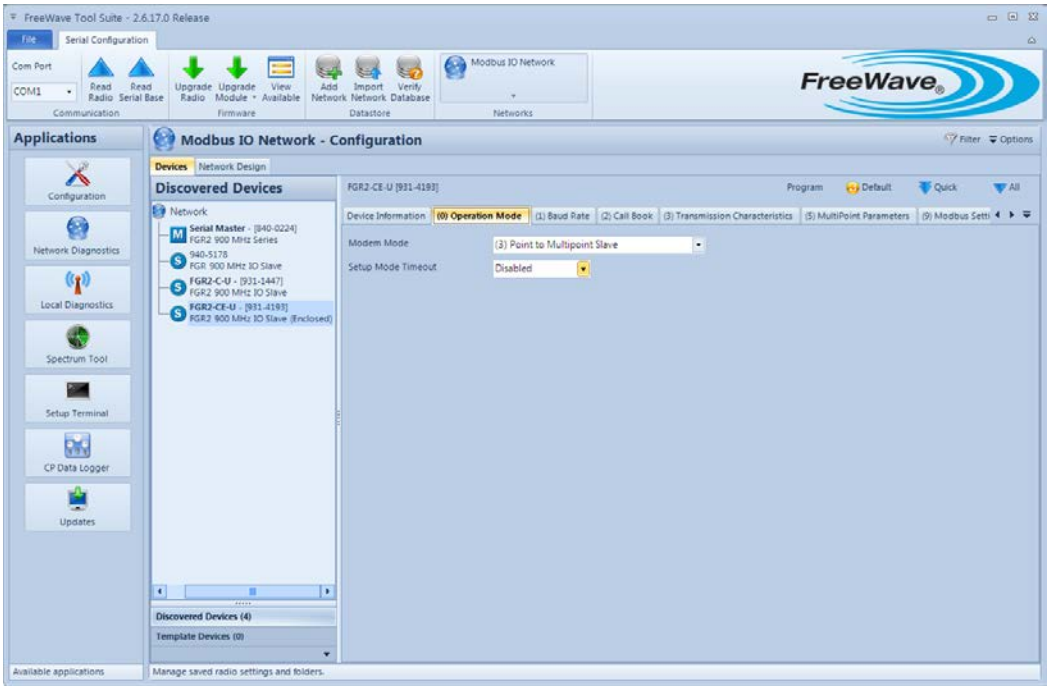
1. DO NOT USE **255**. This enables the Call Book (Menu 2)

iv. Other settings on the **MultiPoint Parameters** tab are to be set at the users' discretion according to the FreeWave User Manual.

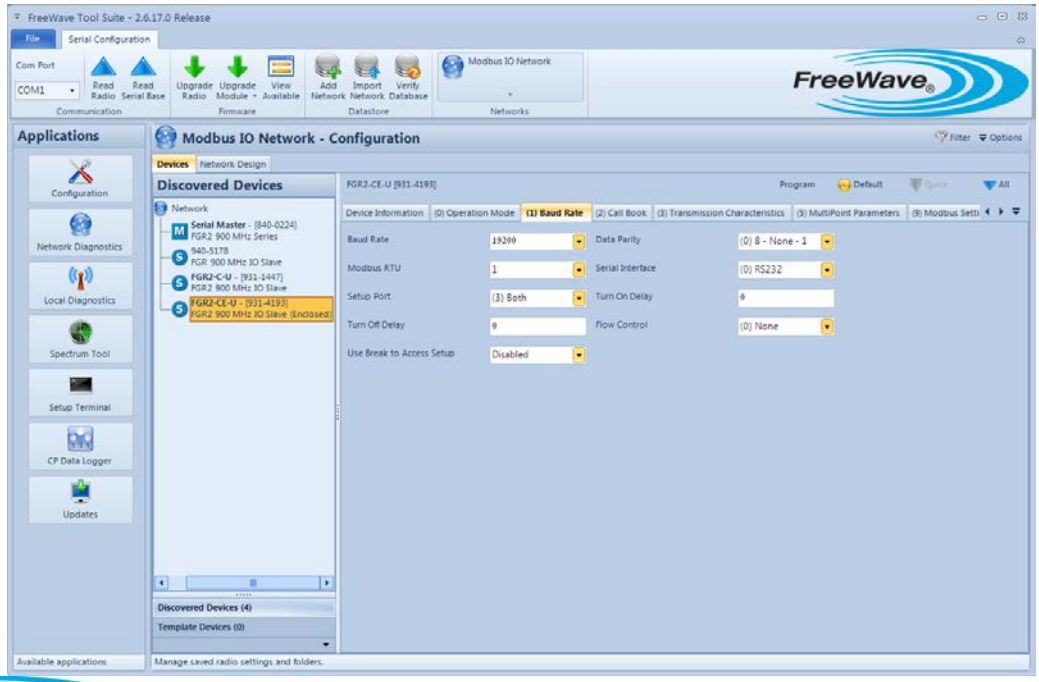
FreeWave Tool Suite - 2.6.17.0 Release
File
Serial Configuration
Com Port
COM1
Read Radio
Read Serial Base
Communication
Upgrade Radio
Upgrade Module
View Available
Firmware
Add Network
Import Network
Verify Database
Datastore
Modbus IO Network
Networks
FreeWave
Applications
Configuration
Network Diagnostics
Local Diagnostics
Spectrum Tool
Setup Terminal
CP Data Logger
Updates
Available applications
Modbus IO Network - Configuration
Filter
Options
Devices
Network Design
Discovered Devices
Network
Serial Master - [840-0224]
FGR2 900 MHz Series
940-5178
FGR 900 MHz IO Slave
FGR2-C-U - [931-1447]
FGR2 900 MHz IO Slave
FGR2-CE-U - [931-4193]
FGR2 900 MHz IO Slave (Enclosed)
Discovered Devices (4)
Template Devices (0)
Serial Master [840-0224]
Program
Default
Quick
All
Device Information
(0) Operation Mode
(1) Baud Rate
(2) Call Book
(3) Transmission Characteristics
(5) MultiPoint Parameters
Repeaters
Enabled
Master Packet Repeat
3
Max Slave Retry
9
Retry Odds
0
DTR Connect
(0) Off
Repeater Frequency
Disabled
Network ID **
1920
Multi-Master Sync
Disabled
1 PPS Enable Delay
255
Slave/Repeater
Disabled
Diagnostics
1
Radio ID
0
Local Mode
Disabled
Radio Name
Serial Master
Rx
Tx
Subnet
F
F
Manage saved radio settings and folders.

Modbus IO Slave Setup

4) Configuring the Modbus IO Slave:
   a. **(0) Operation Mode** Tab
      i. Set the Modbus IO Slave to **(3) Point to Multipoint Slave**.
      ii. DO NOT SET TO **(E) FGRIO Slave (NOT IO-MODBUS)**

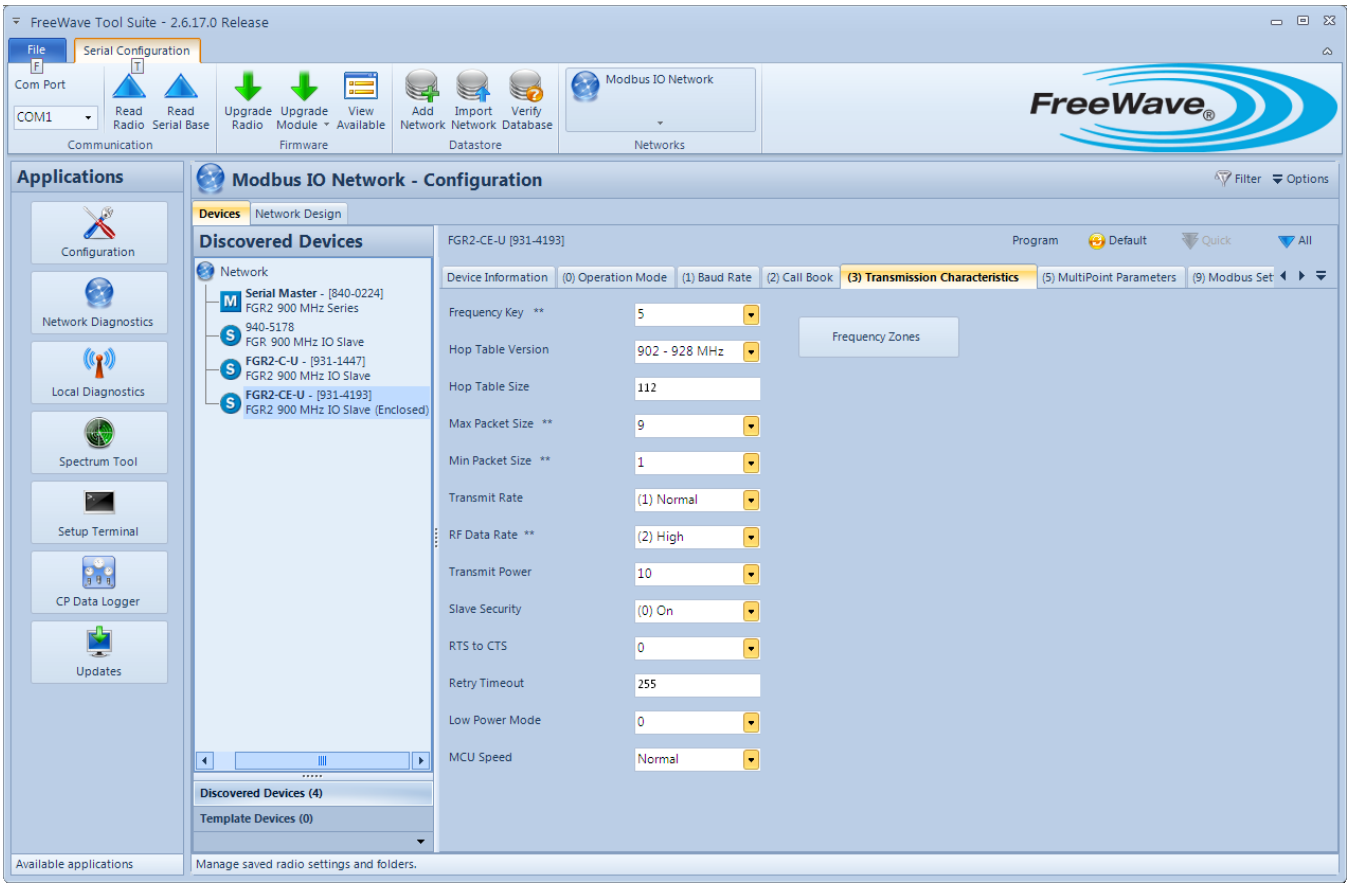


   b. **(1) Baud Rate** Tab
      i. Set **Modbus RTU** to **1**
         1. If a serial device is connected to the data port of the radio the **Baud Rate** and **Data Parity** settings must be set to match the device.



c. **(2) Call Book** Tab
   i. Not applicable - The Call book tab is not used in a Modbus IO system.

d. (3) Transmission Characteristics Tab
   i. Set **Frequency Key** as necessary to match the Serial Master or Repeater.
   ii. Set **Max Packet Size** and **Min Packet Size** to match the Serial Master.
   iii. Set **Retry Timeout**, >= 64 is recommended.
   iv. Other settings on the **Transmission Characteristics** tab are to be set at the users' discretion according to the FreeWave User Manual.



e. **(5) MultiPoint Parameters** tab
   i. Set **Master Packet Repeat** to match the Serial Master.
   ii. Set **Network ID** to match the Serial Master.
   iii. Other settings on the **MultiPoint Parameters** tab are to be set at the users' discretion according to the FreeWave User Manual.

5) **(9) Modbus Settings** Tab

(9) Modbus Settings Tab Descriptions

Option	Function Description	Available in Models
Modbus Mode	For a radio to operate as a Modbus IO Slave, this option must be **Enabled**. If set to **Disabled**, the radio will not respond to Modbus polls.	All Modbus IO Slaves
Modbus Address Size	Set the radio for **8 bit** or **16 bit** Modbus addressing	All Modbus IO Slaves
Modbus ID	Modbus ID is a user -selectable value from **1**– **246** with **Modbus Address Size** set to **8 bit**. With **Modbus Address Size** set to **16 bit** the value is **1-65535**. Each Modbus IO Slave acting as a Modbus device will require a unique Modbus ID.	All Modbus IO Slaves
Sensor Power Default	**Disabled:** Upon power up, before any Modbus commands modifying Sensor Power have been received, the Sensor Power pin will have no voltage applied to it. **Enabled:** Upon power up, before any Modbus commands modifying Sensor Power have been received, the Sensor Power pin will provide voltage equal to the supply voltage of the radio.	All Modbus IO Slaves
AI1 250 Ohms	Places a termination resistor in parallel with the AI1 terminal, converting a 4 – 20 mA signal applied to AI1 into a 1 – 5 V signal.	FGR2-IOS-CE-U **ONLY**

AI1 User Offset	User-entered value that is subtracted from the **AI1 MSW** (Most Significant Word) value. The result is provided in the **AI1 MSW Offset Result** Register value.	All Modbus IO Slaves
Clip AI1 Offset At Zero	**Disabled:** If the value of **AI1 User Offset** is greater than the value of **AI1 MSW**, the value of **AI1 MSW Offset Result** will "wrap around" to the top of the scale. For Example: **AI1 User Offset** = 10000 and **AI1 MSW** = 5000. The value of **AI1 MSW Offset Result** would be 60535. **Enabled:** If the value of **AI1 User Offset** is greater than the value of **AI1 MSW**, the value of **AI1 MSW Offset Result** will be "clipped" at 0 and will not "wrap around" to the top of the scale. For Example: **AI1 User Offset** = 10000 and **AI1 MSW** = 5000. The value of **AI1 MSW Offset Result** would be 0.	All Modbus IO Slaves
AI2 250 Ohms	Places a termination resistor in parallel with the AI2 terminal, converting a 4 – 20 mA signal applied to AI2 into a 1 – 5 V signal.	FGR2-IOS-CE-U **ONLY**
AI2 User Offset	User-entered value that is subtracted from the **AI2 MSW** (Most Significant Word) value. The result is provided in the **AI2 MSW Offset Result** Register value.	All Modbus IO Slaves
Clip AI2 Offset At Zero	**Disabled:** If the value of **AI2 User Offset** is greater than the value of **AI2 MSW**, the value of **AI2 MSW Offset Result** will "wrap around" to the top of the scale. Example: **AI2 User Offset** = 10000 and **AI2 MSW** = 5000. The value of **AI2 MSW Offset Result** would be 60535. **Enabled:** If the value of **AI2 User Offset** is greater than the value of **AI2 MSW**, the value of **AI2 MSW Offset Result** will be "clipped" at 0 and will not "wrap around" to the top of the scale. Example: **AI2 User Offset** = 10000 and **AI2 MSW** = 5000. The value of **AI2 MSW Offset Result** would be 0.	All Modbus IO Slaves
Fast AI (DI 1) Fast AI (DI 2)	**Filtered:** The value reported is an ongoing average of the voltage received by the radio. **Fast:** The value reported is the last sample value of the voltage received by the radio.	All models **EXCEPT** FGRIO-S
Counting Mode	**Fast:** The currently sampled voltage is directly compared to the previous value to determine if the Counter should be incremented. **Debounced:** The voltage is observed over 2 – 3 consecutive samples. Only if all of the sampled values are different from the previous Counter state will the Counter increment. **Filtered:** The currently sampled voltage is compared to an ongoing average of values. If the sampled value is different from the ongoing average, the Counter will be incremented.	All models **EXCEPT** FGRIO-S

DI1 125 Ohms	Places a termination resistor in parallel with the DI1 terminal, converting a 4 – 20 mA signal applied to DI1 into a 0.5 – 2.5 V signal. This should be used if connecting a 4 – 20 mA signal to read AI of DI1.	FGR2-IOS-CE-U **ONLY**
DI1 Pullup	Controls the power-up states of the internal resistor (10 KΩ) connected to DI1. • **(0) Down:** The 10 KΩ internal resistor attached to the input is connected to GND to provide a pulldown for closed-contact-to-voltage sensors. • **(1) Up:** The 10 KΩ internal resistor attached to the input is connected to the 3.3V logic supply to provide a pullup for closed-contact-to-GND sensors. • **(2) None:** The internal resistor is not connected, allowing the connected sensor to provide > 1.75V DC for high and <1.75V DC for low.	All Modbus IO Slaves
DI1 Counter Edge	Determines whether the Counter for DI1 will increment on the **Falling** edge or the **Raising** edge of the voltage reading.	All Modbus IO Slaves
Clear Cntr 1 On Read	**Disabled: DI1 Counter MSW** and **DI1 Counter LSW** will not be automatically cleared. **Enabled:** The values in **DI1 Counter MSW** and **DI1 Counter LSW** are cleared immediately after a Modbus Read command is executed.This can prevent loss of counts which could occur between a Read operation and a later Clear operation. **NOTE: Clear Cntr 1 On Read** only works when both 16 bit registers (**DI1 Counter MSW** and **DI1 Counter LSW)** are read together in a single Modbus poll.	FGRIO-S, FGR2-IOS, and I2-IOS
DI2 125 Ohms	Places a termination resistor in parallel with the DI2 terminal, converting a 4 – 20 mA signal applied to DI2 into a 0.5 – 2.5 V signal. This should be used if connecting a 4 – 20 mA signal to read AI of DI2.	FGR2-IOS-CE-U **ONLY**
DI2 Pullup	Controls the power-up states of the internal resistor (10 KΩ) connected to DI2. • **(0) Down:** The 10 KΩ internal resistor attached to the input is connected to GND to provide a pulldown for closed-contact-to-voltage sensors. • **(1) Up:** The 10 KΩ internal resistor attached to the input is connected to the 3.3V logic supply to provide a pullup for closed-contact-to-GND sensors. • **(2) None:** The internal resistor is not connected, allowing the connected sensor to provide > 1.75V DC for high and <1.75V DC for low.	All Modbus IO Slaves
DI2 Counter Edge	Determines whether the Counter for DI2 will increment on the **Falling** edge or the **Raising** edge of the voltage reading.	All Modbus IO Slaves
Clear Cntr 2 On Read	**Disabled: DI2 Counter MSW** and **DI2 Counter LSW** will not be automatically cleared. **Enabled:** The values in **DI2 Counter MSW** and **DI2 Counter LSW** are cleared immediately after a Modbus Read command is executed.This can prevent loss of counts which could occur between a Read operation and	

	a later Clear operation. **NOTE: Clear Cntr 2 On Read** only works when both 16 bit registers (**DI2 Counter MSW** and **DI2 Counter LSW)** are read together in a single Modbus poll.	
DO Bi-Stable	**Constant:** The DO operates as a bi-stable digitale output. The DO will remain on as long as the coil (**DO1** or **DO2**, see p. 26) is set to **1**. The coil will not be automatically set to **0**. **Auto-Off:** The DO will remain on for the duration set in **DO Monostable Time** (see below) or until the appropriate coil (**DO1** or **DO2**, see p. 26) is set to 0, whichever is shorter. After the **DO Monostable Time** has elapsed, the appropriate coil will be set to **0** (**Off**). The DO will remain off until a **1** is once again written to the appropriate coil.	All Modbus IO Slaves
DO Monostable Time	Sets the length of time a DO will remain on when **DO Bi-Stable** is set to **Auto-Off** (see above). The amount of time is in 150 millisecond increments. The setting can range from **0** (see note) to **255** (approx. 28.25 seconds). **NOTE:** A setting of **0** will cause the DO to turn off at an unspecified amount of time. This time will always be less than 150 milliseconds, but the actual time may vary.	All Modbus IO Slaves
Digital Out 1 Default Digital Out 2 Default	Controls the state of the digital output defaults invoked on loss of communication. See **Default Delay** (below) for timing. **Output ON:** Energized (Contact to GND is closed) **Output OFF:** Not energized (Contact is open) **No Change:** If communication is lost, do not change state.	All Modbus IO Slaves
AO1 Custom Offset	User-entered value that is added to the **AO1 Command** value. The resulting total is the value reported when reading the **AO1 Command** register value.	All models **EXCEPT** FGRIO-S
AO1 Unchanged	Controls the state of AO1 invoked on loss of communication. See **Default Delay** (below) for timing. **Disabled:** If communication is lost, **AO1 Command** will be set to the value in **AO1 Default Cmd**. **Enabled:** If communication is lost, **AO1 Command** will remain set at the last written value.	All models **EXCEPT** FGRIO-S
AO1 Default Cmd	Upon loss of communication, if the **AO1 Unchanged** setting is set to **Disabled** (see above), **AO1 Command** will be set to this value.	All models **EXCEPT** FGRIO-S
AO2 Custom Offset	User-entered value that is added to the **AO2 Command** value. The resulting total is the value reported when reading the **AO2 Command** register value.	All models **EXCEPT** FGRIO-S
AO2 Unchanged	Controls the state of AO2 invoked on loss of communication. See **Default Delay** (below) for timing. **Disabled:** If communication is lost, **AO2 Command** will be set to the value in **AO2 Default Cmd** (see p. 25). **Enabled:** If communication is lost, **AO1 Command** will remain set at the last written value.	All models **EXCEPT** FGRIO-S

AO2 Default Cmd	Upon loss of communication, if the **AO2 Unchanged** setting is set to **Disabled** (see p. 24), **AO1 Command** will be set to this value.	All models **EXCEPT** FGRIO-S
Default Delay	This setting configures the time the radio will wait, after a loss of communication with the Serial Master or Repeater, before the radio enters default condition. This value is in .28 second intervals. e.g. A value of 36 = 36*0.28 sec. = 10.08 sec.	All Modbus IO Models

Modbus Register Map

REGISTER MAP FOR MODBUS IO SLAVES					
COLOR KEY					
Read Only, RO	Read/Write, RW		Non-Volatile on PWR cycle, 10,000-write lifetime limit		New Feature
TYPE	**ADDRESS**		**ENTITY**	**BITS**	**NOTES**
	PROTOCOL	**PLC**			**All addresses described are "PLC" numbers**
Coils, read with command code 01.					
"COIL"	0	1	DO1	1	On Read, returns actual state if ~= Command; Power-up Default = OFF
"COIL"	1	2	DO2	1	On Read, returns actual state if ~= Command; Power-up Default = OFF
"COIL"	2	3	SENSOR PWR	1	On Read, returns actual state if ~= Command
"COIL"	3	4	SENSOR DEFAULT	1	Default = OFF
"COIL"	4	5	DO1 FAULT	1	Auto-Clears fault if successful retry
"COIL"	5	6	DO2 FAULT	1	Auto-Clears fault if successful retry
"COIL"	6	7	SENSOR PWR FAULT	1	Auto-Clears fault if successful retry
"COIL"	7	8	COMM FAIL FAULT LATCH	1	DOx have defaulted, clear by user
"COIL"	8	9	CLR CNTR1 ON RD	1	Default OFF
"COIL"	9	10	CLR CNTR2 ON RD	1	Default OFF
"COIL"	10	11	CNTR1 INC ON 0-1 EDGE	1	Default OFF; Increment on 1-0 Edge
"COIL"	11	12	CNTR2 INC ON 0-1 EDGE	1	Default OFF; Increment on 1-0 Edge
"COIL"	12	13	DO1 LEAVE UNCHANGED	1	Default ON, Overrides DO1 Default
"COIL"	13	14	DO2 LEAVE UNCHANGED	1	Default ON, Overrides DO2 Default
"COIL"	14	15	DO1 DEFAULT STATE	1	Default OFF
"COIL"	15	16	DO2 DEFAULT STATE	1	Default OFF
"COIL"	16	17	CNTR1 INC LATCH	1	ON at inc; OFF by user
"COIL"	17	18	CNTR2 INC LATCH	1	ON at inc; OFF by user
"COIL"	18	19	CNTR1 CLEAR	1	Default OFF, pulsed so Read = always OFF
"COIL"	19	20	CNTR2 CLEAR	1	Default OFF, pulsed so Read = always OFF
"COIL"	20	21	AI1 OFFSET CLIP AT 0	1	Default ON
"COIL"	21	22	AI2 OFFSET CLIP AT 0	1	Default ON
"COIL"	22	23	Reserved	1	
"COIL"	23	24	Ignore Broadcasts	1	Turn OFF to obey broadcasts (ID=0), defaults ON
"COIL"	24	25	DI1 PULLUP	1	Default ON, OFF = PULLDOWN
"COIL"	25	26	DI2 PULLUP	1	Default ON, OFF = PULLDOWN
"COIL"	26	27	DO's BI-STABLE	1	Default ON, OFF = Monostable (1-shot)
"COIL"	27	28	AO1/VSNS LEAVE UNCHANGED	1	Default ON, Overrides AO1/VSNS Default Cmd
"COIL"	28	29	AO2 LEAVE UNCHANGED	1	Default ON, Overrides AO2 Default Command

"COIL"	29	30	DEBOUNCE COUNTERS IN	1	Default ON; OFF for High Speed Counting
"COIL"	30	31	FILTER COUNTERS IN	1	Default ON; OFF for High Speed Counting
"COIL"	31	32	RESET RADIO	1	Always Reads OFF; Write ON for Reset
"COIL"	32	33	FAST AI(DI1)	1	Default ON = Samples, OFF=Filtered Average
"COIL"	33	34	FAST AI(DI2)	1	Default ON = Samples, OFF=Filtered Average
"COIL"	34	35	DI1 PULLUP ACTIVE	1	Default ON; OFF Overrides DI1PULLUP
"COIL"	35	36	DI2 PULLUP ACTIVE	1	Default ON; OFF Overrides DI2PULLUP
"COIL"	36	37	AI1 250 OHM PD ACTIVE	1	Default OFF, Enclosure Model Only
"COIL"	37	38	AI2 250 OHM PD ACTIVE	1	Default OFF, Enclosure Model Only
"COIL"	38	39	DI1 125 OHM PD ACTIVE	1	Default OFF, Enclosure Model Only
"COIL"	39	40	DI2 125 OHM PD ACTIVE	1	Default OFF, Enclosure Model Only
"COIL"	40	41	Reserved	1	
"COIL"	41	42	Reserved	1	
"COIL"	42	43	Reserved	1	
"COIL"	43	44	Reserved	1	
"COIL"	44	45	AI1 250 OHM PD FAULT	1	Enc. Model Only; Auto-Clears if succ. retry
"COIL"	45	46	AI2 250 OHM PD FAULT	1	Enc. Model Only; Auto-Clears if succ. retry
"COIL"	46	47	DI1 125 OHM PD FAULT	1	Enc. Model Only; Auto-Clears if succ. retry
"COIL"	47	48	DI2 125 OHM PD FAULT	1	Enc. Model Only; Auto-Clears if succ. retry
Discrete Inputs, read with command code 02.					
DISCRETE IN	10000	10001	DI1	1	Real-Time state of DI1; "1" = DI1 > 1.75V
DISCRETE IN	10001	10002	DI2	1	Real-Time state of DI2; "1" = DI2 > 1.75V
DISCRETE IN	10002	10003	DI of AI1	1	Compare of AI1: "1" = AI1 > 1.65V
DISCRETE IN	10003	10004	DI of AI2	1	Compare of AI2: "1" = AI2 > 1.65V
DISCRETE IN	10004	10005	DTR	1	Real-Time state of IODTR line on J3

Input Registers, read with command code 04.					
INPUT REG	30000	30001	AI1 MSW	16	Upper 16 bits; msb=5V, lsb=152.587uV
INPUT REG	30001	30002	A1 LSW	16	Lower bits, lsb=2.3283nV
INPUT REG	30002	30003	AI2 MSW	16	Upper 16 bits; msb=5V, lsb=152.587uV
INPUT REG	30003	30004	A2 LSW	16	Lower bits, lsb=2.3283nV
INPUT REG	30004	30005	DI1 COUNTER MSW	16	Upper 16 bits of 32 bit counter
INPUT REG	30005	30006	DI1 COUNTER LSW	16	Lower 16 bits of 32 bit counter
INPUT REG	30006	30007	DI2 COUNTER MSW	16	Upper 16 bits of 32 bit counter
INPUT REG	30007	30008	DI2 COUNTER LSW	16	Lower 16 bits of 32 bit counter
INPUT REG	30008	30009	Vbatt	16	Supply Voltage; 0-33.164V, lsb=32.62mV
INPUT REG	30009	30010	degC	16	Signed degC temperature of radio PCB
INPUT REG	30010	30011	ALL DI'S	16	10016:10001, unused bits = 0's
INPUT REG	30011	30012	ALL COILS 16:1	16	PLC Addresses 16:1, but Read-Only
INPUT REG	30012	30013	ALL COILS 32:17	16	PLC Addresses 32:17, but Read-Only
INPUT REG	30013	30014	AI1 MSW Offset Result	16	AI1 MSW - AI1 USER OFFSET
INPUT REG	30014	30015	AI2 MSW Offset Result	16	AI2 MSW - AI2 USER OFFSET
INPUT REG	30015	30016	AI(DI1)	16	0-3.5Vin; lsb=53.406uV
INPUT REG	30016	30017	AI(DI2)	16	0-3.5Vin; lsb=53.406uV
INPUT REG	30017	30018	AI1	32FP	IEEE754 Short Float in unscaled Volts
INPUT REG	30019	30020	AI2	32FP	IEEE754 Short Float in unscaled Volts
INPUT REG	30021	30022	AI(DI1)	32FP	IEEE754 Short Float in unscaled Volts
INPUT REG	30023	30024	AI(DI2)	32FP	IEEE754 Short Float in unscaled Volts
INPUT REG	30025	30026	Vbatt	32FP	IEEE754 Short Float in unscaled Volts
INPUT REG	30027	30028	degC	32FP	IEEE754 Short Float in unscaled Celsius
INPUT REG	30029	30030	DO1 CURRENT	16	lsb=534uA, Res=34mA; Not Accurate in Fault
INPUT REG	30030	30031	DO2 CURRENT	16	lsb=534uA, Res=34mA; Not Accurate in Fault
INPUT REG	30031	30032	Reserved1	16	
INPUT REG	30032	30033	Reserved2	16	
INPUT REG	30033	30034	ALL COILS 48:33	16	PLC Addresses 48:33, but Read-Only
INPUT REG	30034	30035	Reserved		
INPUT REG	30035	30036	Reserved		
INPUT REG	30036	30037	Reserved		
INPUT REG	30037	30038	Discrete In 16:1	16	PLC Addrs 16:1, Read-Only, MSB=16, LSB=1
INPUT REG	30038	30039	Reserved		
INPUT REG	30039	30040	Reserved		
INPUT REG	30040	30041	Reserved		
INPUT REG	30041	30042	Reserved		
INPUT REG	30042	30043	Reserved		

Holding Registers, read with command code 03.					
HOLDING REG	40000	40001	ALL COILS 16:1	16	PLC Addresses 16:1
HOLDING REG	40001	40002	ALL COILS 32:17	16	PLC Addresses 32:17
HOLDING REG	40002	40003	DO's DEFAULT DELAY	16	.28 sec units of Retry Timeout to DO Defaults
HOLDING REG	40003	40004	AI1 USER OFFSET	16	Value to subtract from 30001 for 30014
HOLDING REG	40004	40005	AI2 USER OFFSET	16	Value to subtract from 30002 for 30015
HOLDING REG	40005	40006	DO MONOSTABLE TIME	16	Duration of DO ON, if 27 OFF, ~.15sec/count, range 0-255
HOLDING REG	40006	40007	AO1 Command	16	0-22mA: lsb=335.693nA
HOLDING REG	40007	40008	AO2 Command	16	0-22mA: lsb=335.693nA
HOLDING REG	40008	40009	AO1/VSNS Default Cmd	16	0-22mA: lsb=335.693nA
HOLDING REG	40009	40010	AO2 Default Command	16	0-22mA: lsb=335.693nA
HOLDING REG	40010	40011	AO1 Customer Offset	16	Added to 40007 lsb=335.693nA
HOLDING REG	40011	40012	AO2 Customer Offset	16	Added to 40008 lsb=335.693nA
HOLDING REG			Reserved		
HOLDING REG			Reserved		
HOLDING REG			Reserved		
HOLDING REG			Reserved		
HOLDING REG	40033	40034	ALL COILS 48:33	16	PLC Addresses 48:33, but Read-Only
HOLDING REG	40034	40035	Reserved		
HOLDING REG	40035	40036	Reserved		
HOLDING REG	40036	40037	Reserved		
HOLDING REG	40037	40038	Discrete In 16:1	16	PLC Addrs 16:1, Read-Only, MSB=16, LSB=1
HOLDING REG	40038	40039	Reserved		
HOLDING REG	40039	40040	Reserved		
HOLDING REG	40040	40041	Reserved		
HOLDING REG	40041	40042	Reserved		
HOLDING REG	40042	40043	Reserved		
HOLDING REG	42000	42001	DI1	1	Real-Time state of DI1; "1" = DI1 > 1.75V
HOLDING REG	42001	42002	DI2	1	Real-Time state of DI2; "1" = DI2 > 1.75V
HOLDING REG	42002	42003	DI of AI1	1	Compare of AI1: "1" = AI1 > 1.65V
HOLDING REG	42003	42004	DI of AI2	1	Compare of AI2: "1" = AI2 > 1.65V
HOLDING REG	42004	42005	DTR	1	Real-Time state of IODTR line on J3

Explanatory Notes by PLC Address:

Note: The radio will treat requested register addresses below 00256 as implicitly referencing higher registers according to the command code issued.

- For example, a command to “Read Holding Register 00003” will return the contents of register 40003, as the Holding Registers all reside at 40000 and above.
- Similarly, a command to “Read Discrete Input 00002” will return the state of address 10002.
- A request to “Read Coil 00002” will return the state of address 00002, as the coils actually are resident at addresses below 256.

Modbus Register Descriptions

1 DO1; DISCRETE OUTPUT #1

Emulates a contact closure to GND using a solid-state device. Rated current is 2.0 Amps maximum; protection algorithms will shut OFF the DO at about 2.25 Amps. See “coil” 5 for Fault sensing and coils 13, 15 and register 40003 for Default settings. Coil 27 and Register 40006 allow automatic shut OFF of the DO after an interval.

2 DO2; Similar operation to DO1

3 SENSOR POWER

Radio power-on default controlled by coil 4. See coil 7 for Fault sensing. The I/O terminal is now shared with Analog Output AO1. Activation of this coil overrides any setting of AO1.

4 SENSOR POWER-ON DEFAULT

Factory Pre-set to ON.

5 DO1 FAULT

DO1 Current is sensed and turned OFF if > 2.25A nominal, resulting in ON condition of this synthetic “coil”. Radio periodically turns DO1 back ON and checks for persistence of Fault. If Fault condition ends, this coil automatically reverts to OFF.

6 DO2 FAULT; Similar operation to coil 5.

7 SENSOR POWER FAULT

Similar operation to coils 5, 6, except Fault threshold is >50mA. An algorithm allows the Fault threshold to be exceeded for several milliseconds to allow charging of external sensor bypass capacitors. Sensors having large bypass capacitance may nevertheless force this Fault and not be usable with the Sensor Power output. Such devices may be low-side switched with a DO or permanently powered by B+ IN.

It is possible to achieve an extra pseudo-DI function by powering a resistor sized to draw approximately 100mA from Sensor Power connected to a contact closure whose other side is GND. Closure causes a “1” on Read of this coil. Since the re-try duty cycle of the 100mA current is low, only about 1mA of extra average supply current results. Any powered sensors present would need to be powered by direct connection to B+ IN.

8 COMM FAIL FAULT LATCH

In case of communication failure, DO’s can be set up to go to Default states under control of coils 13-16. This coil serves to inform (after communication is restored) that the link was lost long enough to activate the Defaults. This coil remains ON until turned OFF by Modbus command.

9 CLEAR COUNTER 1 ON READ

If ON, this coil causes the DI1 counter to be cleared automatically when Read, preventing loss of counts occurring between a Read and subsequent Clear (see coil 19). This coil only functions if the Read is of both registers 30005 and 30006. Factory

Pre-set is OFF, so that DI1 Counter accumulates up to maximum value of 4,294,967,295.

10 CLEAR COUNTER 2 ON READ; Similar operation to coil 9.

11 CNTR1 INC ON 0-1 EDGE

Factory Pre-set is OFF, so that falling edges of DI1 cause the Counter to increment. Change of this setting by Modbus command may cause a false increment.

12 CNTR2 INC ON 0-1 EDGE; Similar to coil 11.

13 DO1 LEAVE UNCHANGED

Factory Pre-set ON. Users may not want the radio to automatically enter defined Default states after communication loss. This coil takes precedence over the Default State setting of coil 15.

14 DO2 LEAVE UNCHANGED; Similar to coil 13.

15 DO1 DEFAULT STATE

Factory Pre-set OFF. If coil 13 is OFF and communication is lost longer than the timeout of register 40003, DO1 will go to the state of this coil.

16 DO2 DEFAULT STATE; Similar to coil 15.

17 CNTR1 INC LATCH

Power-on state is OFF. Latch is set ON when an increment event occurs on DI1 and can only be cleared to OFF by Modbus command. This is useful for single event detection, such as plunger arrival.

18 CNTR2 INC LATCH; Similar to coil 17

19 CNTR1 CLEAR

Forced reset to zero of DI1 Counter. Setting this coil to ON clears the counter and this coil, so that a Read of this coil is always OFF.

20 CNTR2 CLEAR; Similar to coil 19.

21 AI1 OFFSET CLIP AT 0

ON: Unsigned Offset calculation (30014 = 30001 - 40004) forced to zero in case: 40004 > 30001. OFF: Unsigned Offset calculation (30014 = 30001 - 40004) allowed to wrap in case: 40004 > 30001. For example, if 40004 = 30001 + 1, 30014 = 65,535.

22 AI2 OFFSET CLIP AT 0; similar to coil 21.

25 DI1 PULLUP

Default is ON; a 10Kohm internal resistor attached to the input is connected to the 3.3V logic supply to provide a pullup for closed-contact-to-GND sensors. Turning this coil OFF connects the resistor as a pulldown to GND for use with closed-contact-to-voltage sensors.

26 DI2 PULLUP; similar to coil 25.

27 DO's BI-STABLE

Default is ON; states of DO1 and DO2 are persistent unless changed by Modbus command or Communication Loss Defaults.
If coil 27 is reset to OFF (mono-stable), a DO ON state will timeout after an interval set in register 40006. In case a Communication Loss Default turns ON the DO, a single ON interval will occur even if the link repeatedly restores and fails. Clearing the Comm Fail Fault Latch at coil 8 will re-arm for Communication Loss Default events to turn ON the DO. Each actual Modbus ON command to a DO results in a new ON interval.
The automatic timeout mode is useful if the DO is connected to a device which is not rated for continuous ON, so that link or SCADA outages don't damage it. Also, Modbus traffic may be reduced, as the need to command a DO back OFF may be eliminated.

28 AO1/VSNS LEAVE UNCHANGED

Default is on, this causes the AO to stay at its current state when the radio goes to default conditions. This Over rides the default state in Holding Register 40009.

29 AO2 LEAVE UNCHANGED

Default is on, this causes the AO to stay at its current state when the radio goes to default conditions. This Over rides the default state in Holding Register 40010.

30 DEBOUNCE COUNTERS

Default is on. See **Debounced**, p. 22

31 FILTER COUNTERS

Default is on. See **Filtered**, p. 22

32 RESET RADIO

Write ON to reset the radio. This is mostly for Modbus parsing in the menu's, used to reset the radio to get back to operation mode.

33, 34 FAST AI(DI1)/FAST AI(DI2)

On is raw fast, no filtering, AI(DI), Off is filtered average.

35, 36 DI1/DI2 PULLUP ACTIVE

On leaves DI pull up enabled, default condition. Off turns off DI pull up.

37,38 AI1AI2 250 OHM PD ACTIVE

On turns on 250 ohm termination resistor for AI, turning 4-20 mA signal into 1-5V for sampling. Only on the enclosed models.

39, 40 DI1 125 OHM PD ACTIVE

On turns on 125 ohm termination resistor for DI. Only on the enclosed models.

45,46 AI1/AI2 250 OHM PD FAULT

On means current through 250 ohm termination resistor for AI was too high, termination resistor is disabled, this coil will clear when the termination resistor is retried and isn't in a fault condition.

47, 48 DI1/DI2 125 OHM PD FAULT

On means current through 125 ohm termination resistor for AI3/4 was too high, termination resistor is disabled, this coil will clear when the termination resistor is retried and isn't in a fault condition.

10001 DI1

The present state of DI1. Logic threshold is 1.15 to 2.15V.

10002 DI2; Similar to register 10001.

10003 DI OF AI1

The most recent conversion of AI1 compared to a threshold of 1.65V exactly. This comparison is made at 330msec intervals and no counting or latching functions are available. Useful for slow devices such as float switches. The AI's present a 136 Kohm resistance to GND, so a pullup resistor is required when using a contact to GND or open collector as the source.

10004 DI OF AI2; Similar to register 10003.

10005 DI of IODTR

Pin 3 of the J3 10-pin connector can be used as an auxiliary DI. The pin presents a 3 Kohm to 7 Kohm resistance to GND and a threshold voltage of up to 2.4V. For use with a contact to GND or open collector, a pullup resistor must be supplied able to pull the input above 2.4V. For example, a recommended resistor for a 12V pullup source would be 8.2 Kohm or less.

30001 AI1 MSW

The Most Significant Word of the AI1 conversion. One least-significant-bit (lsb) = 152.587uV. Although full scale would be 10V, the hardware limits the maximum to 5.625V. Most users will only require this MSW.

30002 AI1 LSW

For those users requiring the maximum possible resolution, the final 5 bits of the AI1 conversion are here, left-justified, so that the MSW, LSW register pair can be regarded as a 32-bit unsigned integer with 10V = $FFFFFFFF.

30003 AI2 MSW; Similar to 30001.

30004 AI2 LSW; Similar to 30002.

30005 DI1 COUNTER MSW

The upper 16 bits of a 32 bit DI1 counter (unsigned) formed by registers 30005, 30006. Counter is controlled by coils 9, 11, 19. Maximum count rate is dependant on Max, Min Packet Sizes; sizes 2, 2 allow counting of as low as 20msec per phase (both “1” and “0”), while sizes 9, 9 allow only down to 50msec per phase.

30006 DI1 COUNTER LSW

The lower 16 bits of the 30005, 30006 Counter. Many customers will only use this LSW, but if the Clear-On-Read function of coil 9 is desired, both registers must be Read in a single command.

30007 DI2 COUNTER MSW; Similar to 30005.

30008 DI2 COUNTER LSW; Similar to 30006.

30009 VBATT

The supply voltage to the radio as an unsigned integer in units of 506.04uV per lsb. Useful for remote monitoring of battery charge.

30010 DEGC

The temperature of the radio PCB as a signed integer with units of 1 degree Celsius per lsb.

30011 ALL DI’S

For convenience, all the DI’s are combined in a single word, with DI1 as lsb and unused bits Read as “0”.

30012 ALL COILS 16:1

For convenience, coils 16:1 are combined in a single word, with coil 1 as lsb.

30013 ALL COILS 32:17

For convenience, coils 32:17 are combined in a single word, with coil 17 as lsb. Unused bits are Read as “0”.

30014 AI1 MSW Offset Result

Some customer Modbus controllers lack a convenient means of adjusting Modbus AI readings for offset. For example, a 1-5V pressure transmitter would define 0 psi as a 1.00V output, for which the AI1 conversion MSW would be 6553. For convenience, the user can enter an unsigned integer (such as 6553) in register 40004 which will be subtracted from the AI1 MSW of register 30001 and the unsigned result placed here. No provision for multiplicative scaling is made and no corrected LSW is available. Also, negative results may be forced to $0000 according to coil 21, or allowed to wrap modulo 65,536.

30015 AI2 MSW Offset Result; Similar to 30014.

30016 AI(DI1)

An analog voltage applied to the DI1 terminal is measured and can be read at this register. Range of the input is 0-3.5V with scale of 53.406uV/lsb. The converter used has 10-bit resolution. If you are using a wiring set-up that halves the voltage from the 1-5V sensor, the digitized value of the DI voltage will represent the actual (halved) voltage at the DI. The scaling factor of 53.406uV/lsb keeps this halved voltage. To obtain the voltage level read by the 1-5V sensor before it was halved, you must multiply the voltage read from register 30016 by a factor of two. A simple digital lowpass filter is applied to reduce the effect of random noise and has a packet-size dependant time constant of about .5 to 2 seconds. The filters' effectiveness against coherent signals, such as power line interference, varies with packet size in a complicated manner. Some combinations of packet size, interfering frequency and accuracy needed will require the interfering signal be mitigated with external filtration or shielding.

30017 AI(DI2); similar to 30016.

30018, 30019 AI1 SHORT FLOAT

This register pair, which should be read together, forms an IEEE754 standard Short (32 bit) Floating Point number which is the value in register 30001 (AI1 MSW) converted to an un-scaled voltage. Neither register 30002 (AI1 LSW) nor 40004 (AI1 User Offset) contribute to this value.

30020, 30021 AI1 SHORT FLOAT; similar to 30018, 30019.

30022, 30023 AI(DI1) SHORT FLOAT; similar to 30018, 30019.

30024, 30025 AI(DI2) SHORT FLOAT; similar to 30018, 30019.

30026, 30027 VBATT SHORT FLOAT; similar to 30018, 30019.

30028, 30029 DEGC SHORT FLOAT; similar to 30018, 30019. Units are degrees Celsius.

30030 DO1/DO2 CURRENT
Current measurement of DO, least significant bit is 916uA, not accurate during protection as circuit is open, not conducting current.

30034 ALL COILS 33:48
Coils 33:48 mapped into an input register, similar to 30012,30013.

30038 DISCRETE IN 1:16
Discrete inputs 1:16 mapped into an input register. Most significant bit is discrete input 16, least significant bit is input 1.

40001 ALL COILS 16:1 READ ONLY
Holding Register combining coils 16:1 in a single register.

40002 ALL COILS 32:17 READ ONLY
Holding Register combining coils 29:17 in a single register.

40003 DO's DEFAULT DELAY
The duration in units of 1/3 second that the radio DO's will hold their current values while searching for the network before invoking the Default settings of coils 13-16.

40004 AI1 USER OFFSET
An unsigned integer to be subtracted from the AI1 MSW at register 30001, with the result placed in register 30014. Useful for translating offset sensors such as 1-5V or 4-20mA types so that their minimum output Reads as $0000 in register 30014.

40005 AI2 USER OFFSET; Similar to 40004.

40006 DO MONOSTABLE TIME
If coil 27 is OFF, this register sets the time interval before a DO in the ON state will be automatically shut OFF. Range is 0-255 in units of ~.15 second.

40007, 40008 AO1/AO2 Command
Analog value to be output on AO. Least significant bit corresponds to 335.693 nA. Nominal range is from 0-22 mA.

40009, 40010 AO1/AO2 Default Command.
AO command value in default conditions.

40011, 40012 AO1/AO2 Customer Offset
AO customer offset. Added to AO command before output.

42001-42005 Discrete inputs mapped to individual holding registers.
Discrete inputs mapped into individual input registers. If discrete input 10001 = On, then 42001 = 1, if 10001 = Off, then 42001 = 0. The 2000 address shift may change in future firmware revisions. This is not recommended, use Holding 40038 or Discrete Inputs.

Installation of the Modbus IO Slave

(1) Battery or Power Supply

Screw Terminal #11 (B+ In) on the terminal block of the Modbus IO Slave is the raw power for the radio. This terminal is directly connected to Pin # 1 on the 10 pin white header of the Modbus IO Slave. Either one can be used to power the radio.

(2) 1 – 5 Volt Sensor

Analog Input 1 or Analog Input 2

For connection to either Analog Input 1 or Analog Input 2, the 1-5 volt sensor can be wired to the Modbus IO Slave with a 3 wire connection.

- The Sensor Ground Wire can be connected to Ground Screw Terminal #3, 9, or 12 on the terminal block of the Modbus IO Slave.
- The Sensor Power Wire is connected to the VSNS screw terminal #7 on the terminal block of the Modbus IO Slave. Rated total current draw from VSNS is 40 mA or less.
- Sensor Output Wire is connected to Analog Input 1 screw terminal #8 or Analog Input 2 screw terminal #10 on the terminal block of the Modbus IO Slave.

The existing AIs at screw terminal #8 and screw terminal #10 are usable with .1V to 5.625V input voltages (compatible with most 1-5V and 4-20mA transmitters) and load the input with about 100Kohm to GND. They also offer accuracy of +/-.1% with 16 bit resolution and are therefore recommended for the most critical variables in a system.

Analog Input 3 or Analog Input 4

The Digital Inputs (DIs) of the Modbus IO Slave may be digitized to 10 bit resolution and read directly by the Modbus. This allows up to 4 analog transducers to be connected to a single remote Modbus IO Slave. (**NOTE:** In the FGRIO-S radio, this feature requires a firmware version of 2.65IO or higher)

The AIs formed from the DIs at screw terminal #1 and screw terminal #2 are directly usable with signals only from .1V to 2.812V in wire replacement mode. Input loading can be selected as 10Kohm to GND or unloaded (>1Megohm) (Options E and F on Menu 9, FGRIO Setup) Accuracy is within +/-.25% and resolution is 10 bits. The next section describes methods to best apply inputs to them.

Signal Coupling for Analog Input 3 and Analog Input 4.

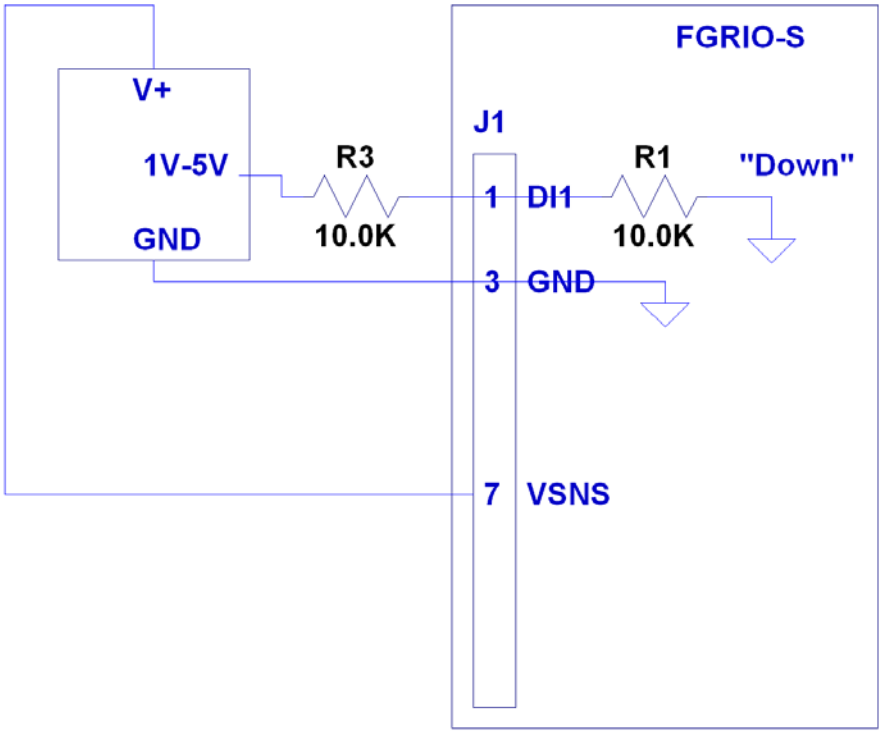
1). Input Resistor
The Modbus IO Slave DIs have always provided an internal 10Kohm resistor pull-up to the radio's 3.3V logic supply. With new firmware 2.65IO on the FGRIO-Slave, or any firmware version on the FGR2-IO or I2-IO Slave, the resistor can also be commanded (in the Modbus IO Setup menu) to pull down to GND or "float" unconnected. As will be shown, these options are useful for connection of analog inputs.

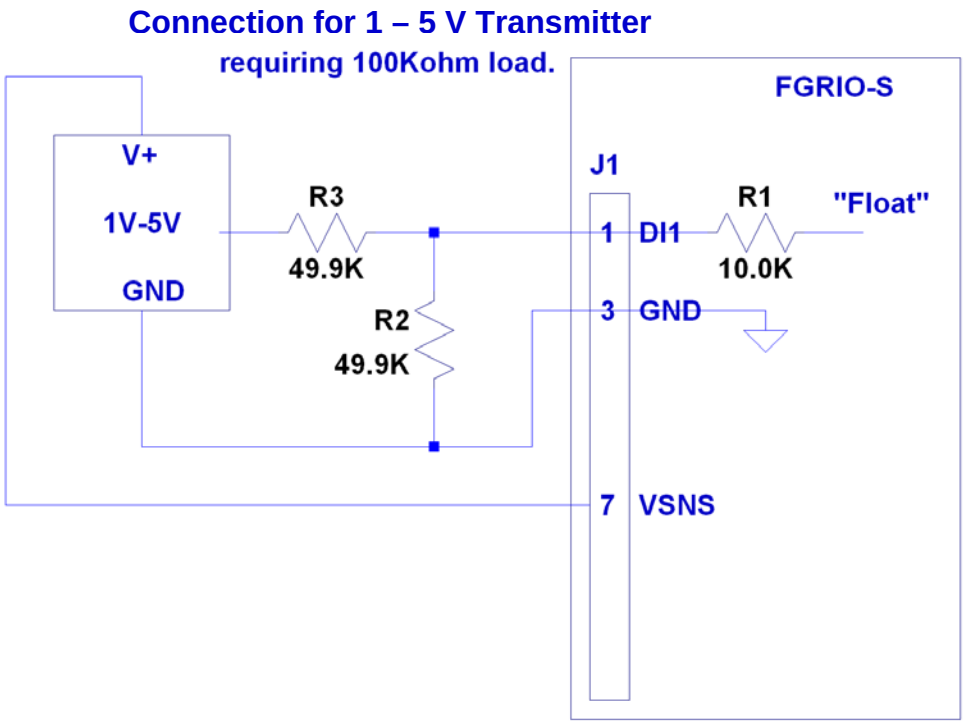
2). Signal Level Reduction.
As stated above, the DI does not have sufficient voltage range for direct connection to typical transducer outputs, so the input must be restricted. In Modbus, the voltage at the DI is simply digitized for a subsequent register poll.

3). VSNS Sensor Power
The switched voltage source at screw terminal #7 is designed to drive only two 4-20mA transmitters to full scale. Voltage output (1-5V) transmitters usually consume less current and may allow up to 4 to be switched.

Below are two diagrams showing the connection of a 1-5V sensor to Analog Input #3:

Connection for 1 – 5 V Transmitter to DI1 or DI2





(3) 4-20 Milliamp Sensor

Analog Input 1 or Analog Input 2

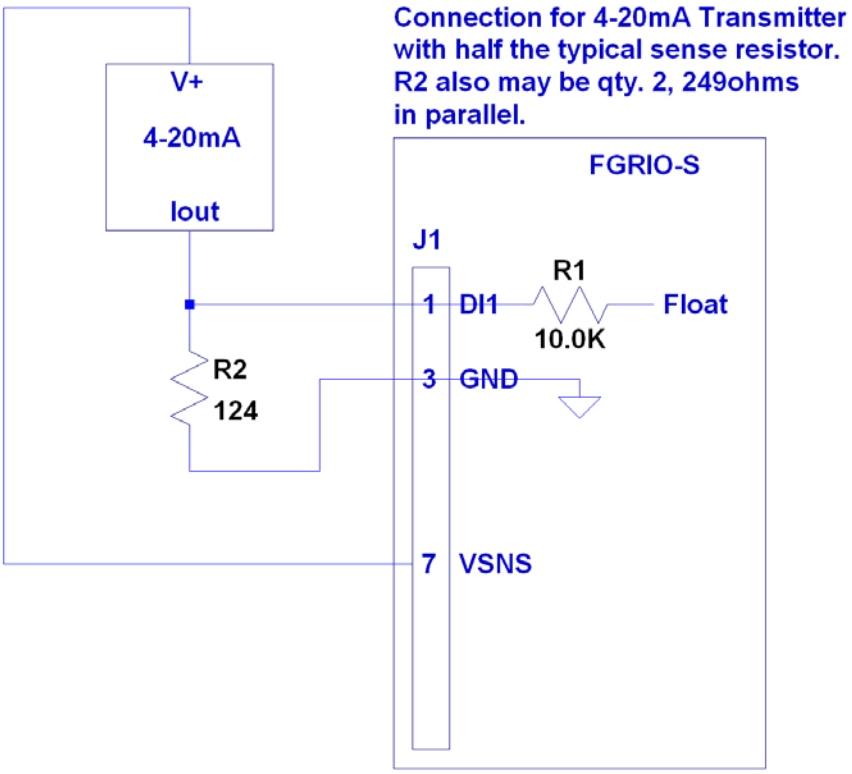
For connection to either Analog Input 1 or Analog Input 2, the 4-20 milliamp sensor can be wired to the Modbus IO slave with a 2 wire connection.

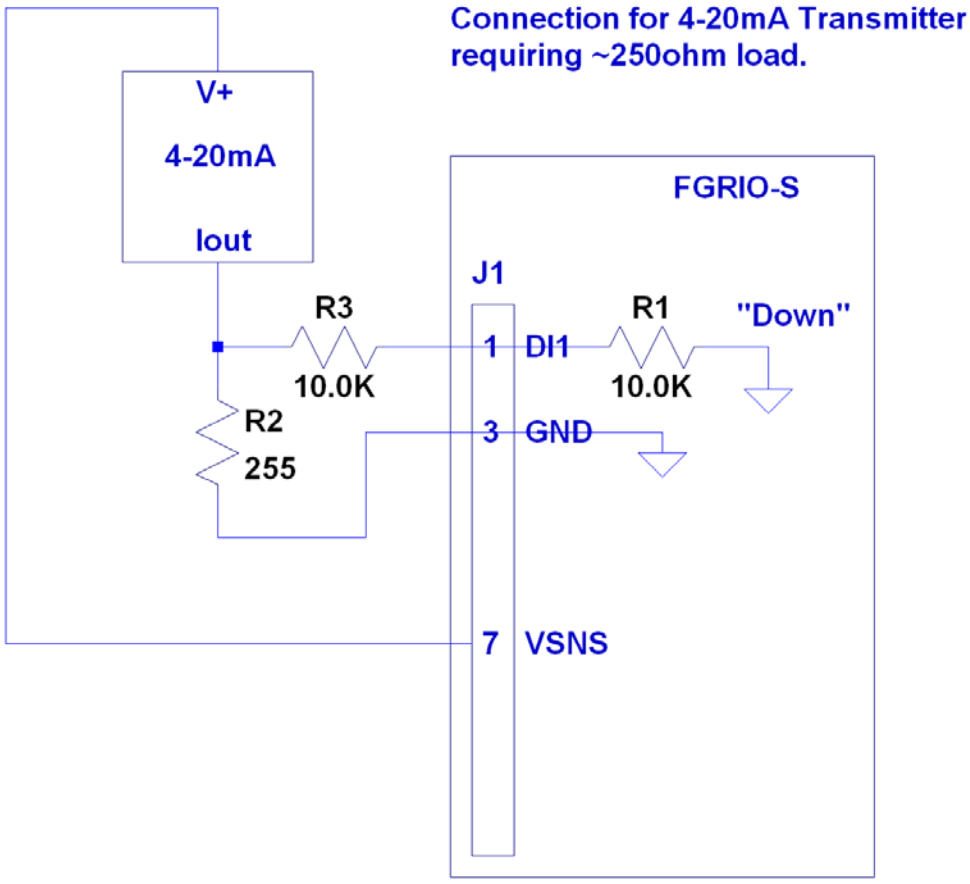
- An external resistor (typically 249 Ohms) is required to convert 4-20 milliamps to 1-5 volts. The resistor goes from the desired Analog Input to Ground screw terminals on the terminal block of the Modbus IO Slave.
- Sensor Power Supply (High) Wire is connected to VSNS screw terminal #7 on the terminal block of the Modbus IO Slave.
- Sensor Output (Low) Wire is connected to the same Analog Input as the resistor on the terminal block of the Modbus IO Slave.

Analog Input 3 or Analog Input 4

The same accuracy and signal level reduction considerations stated under section **(2) 1-5 Volt Sensor, Analog Input 3 or Analog Input 4** (see p. 37), apply when using a 4-20 milliamp sensor. The switched voltage source at screw terminal #7 is designed to drive only two 4-20 mA transmitters to full scale. If a system will use more than two, the additional transmitters must be powered from a separate supply, such as directly from the battery or another DC supply.

Below are two diagrams showing the connection of a 4-20 milliamp sensor to Analog Input 3:





(4) Digital Input 1 and Digital Input 2

To connect a digital input to the Modbus IO Slave:

- Switch Output Wire is connected to Digital Input 1 screw terminal # 1 or Digital Input 2 screw terminal # 2 on the block terminal of the Modbus IO Slave.
- Switch Ground Wire is connected to Ground screw terminal # 3, 9 or 12 on the terminal block of the Modbus IO Slave.
- If the Switch Ground Wire is not returned to the Modbus IO Slave, the potential difference between the Modbus IO Slave Ground and the Dry Contact Closure (Switch) Ground should not exceed 1 Volt.
- In the case of a 3 wire digital transducer, set up similarly to the 1-5V analog sensor, except with the signal wire connected to a Digital Input.

(5) Digital Output 1 and Digital Output 2

To connect a device to the digital output:

- Connect the appropriate terminal on the device to DO1 (terminal #4) or DO2 (terminal #5).
- Power the device from the same power source as the Modbus IO Slave.
- Use Modbus commands to turn the digital output **ON** and **OFF**. When the output is turned **ON**, it will sink up to 2A to ground. When the output is turned **OFF**, the output will be floating.

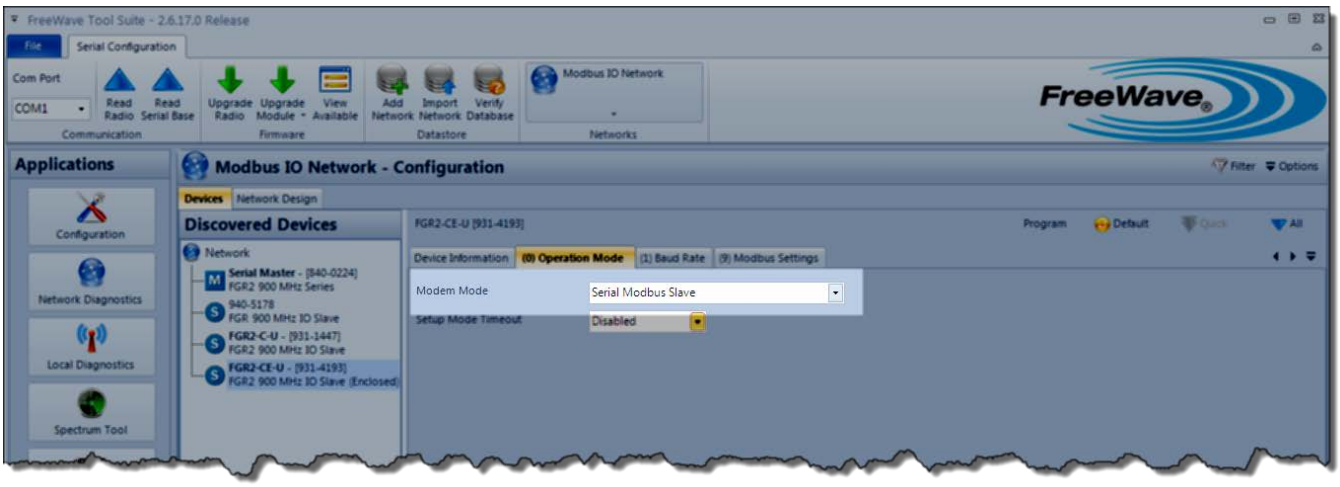
Serial Modbus Slave Mode

Configuration Instructions for Serial Modbus Slave in Wired Applications

The **Serial Modbus Slave** operating mode in the FGR2-IO-IOE, FGR2-IOS-CE and FGR2-IOS-C radios allow users to install it like an expansion module. In this mode, the radio's RF transceiver is disabled while keeping the I/O interfaces active. The device responds to polls issued directly to its serial data port. **Serial Modbus Slave** is available starting in firmware versions 9.75.

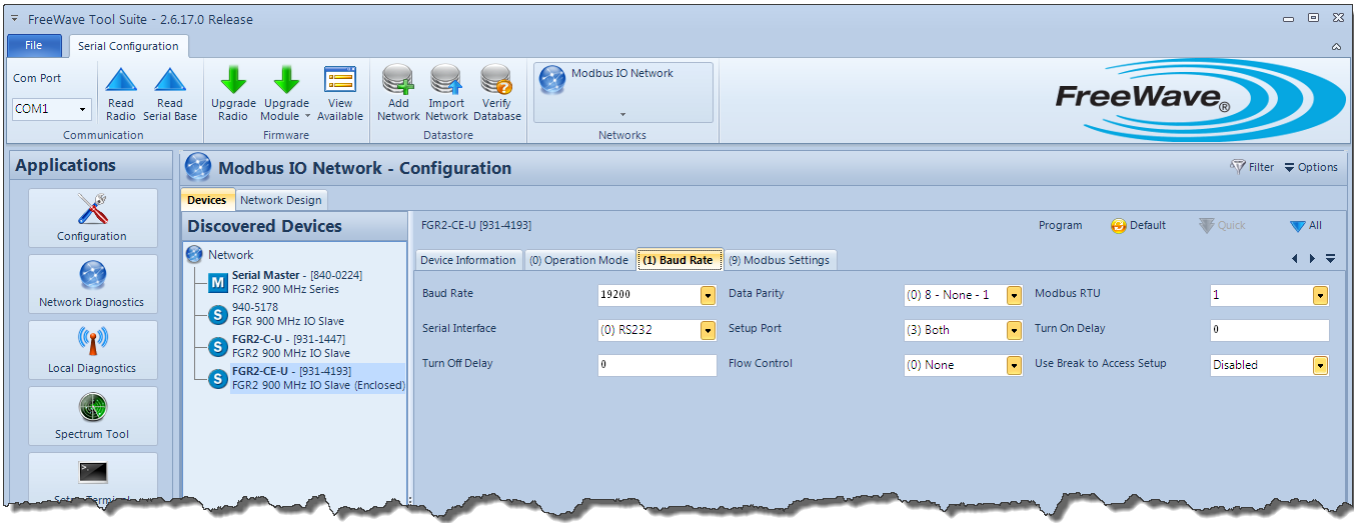
The following steps outline the configuration settings to use the Serial Modbus Slave operating mode with Tool Suite:

1. **(0) Operation Mode** Tab



   a. Set **Modem Mode** to **Serial Modbus Slave**. In this mode there will only be 3 accessible configuration tabs.

2. **(1) Baud Rate** Tab



   a. Set the following settings to match the serial port that will be connected
      i. Baud Rate

ii. Data Parity
iii. Serial Interface
iv. Flow control
v. Turn On Delay (if necessary)
vi. Turn Off Delay (if necessary)

3. **(9) Modbus Settings** Tab

a. Modbus Mode: Set to “Enabled”
b. Modbus Address Size: Set to desired addressing mode, typically “8 bit”
c. Modbus ID: Each device must have its own Modbus ID. Choose a unique Modbus ID for this device.
d. For the channel configuration settings, consult the detailed descriptions for the **(9) Modbus Settings** Tab on page 21.

Technical Specifications
FGRIO-S Specifications

Transceiver	
Frequency Range	902 – 928 Mhz
Output Power	100 mW
Range, Line-of-sight	2 miles
Modulation	2 level GFSK
Occupied Bandwidth	230 kHz
Hopping Patterns	15, user selectable
Hopping Channels	50 to 112, user selectable
Hopping Bands	7, user selectable
RF Connector	SMA female
Receiver	
Sensitivity	-98 dBm at 10^{-6} BER -100 dBm at 10^{-4} BER
Selectivity	20 dB at fc ± 115 kHz 60 dB at fc ± 145 kHz
System Gain	130 dB
Data Transmission	
Error Detection	32 bit CRC, retransmit on error
Link Throughput	115.2 Kbps
Data Interface	Serial
Protocol	RS-232/422/485, 300 baud – 115.2 Kbaud
Data Connector	10-pin header
Analog Inputs	
Number of Inputs	2
Accuracy, Resolution	± 0.1%, 16 bit
Input Range	0.2 – 5.62 V, 94 KΩ input resistance
Digital Inputs	
Number of Inputs	2
Input Pull-up	10 KΩ to 3.3 V
Input Pull-down	10 KΩ to GND
Input Connector	Mini Phoenix (3.55 mm)
Slave Input to Master Output Delay	1 sec. maximum
Signal Input Voltage Maximum	± 20 V
Maximum Count Size & Rate	32 bits, 1000 Hz
AI of DI Accuracy, Resolution	± 0.25%, 10 bit
AI of DI Input Range	0 – 3.5 V
Digital Output	
Number of Outputs	2
Current Rating	2 Amps maximum
Voltage Rating	Lesser of: 20 V or the radio supply voltage
Diagnostic Interface	
Connector	Separate 20-pin PCB header
Power Requirements	
Operating Voltage	6 to 20 V DC
Average Current Usage	**Mode** / **6 V DC** / **12 V DC** / **20 V DC** **Transmit** / 120 mA / 68 mA / 48 mA **Receive** / 68 mA / 38 mA / 28 mA **Linked** / 12 mA / 7 mA / 6 mA
General Information	
Operating Temperature Range	-40° C to +75° C
Dimensions	138 mm L x 76 mm W x 12 mm H
Weight	58 g
Humidity	0 to 95% non-condensing

FGR2-IOS-C-U/FGR2-IOS-CE-U Specifications

Transceiver	
Frequency Range	902 – 928 Mhz
Output Power	5 mW to 1 W (+30 dBm)
Range, Line-of-sight	60 miles
Modulation	2 level GFSK
Occupied Bandwidth	230 kHz
Hopping Patterns	15, user selectable
Hopping Channels	50 to 112, user selectable
Hopping Bands	7, user selectable
RF Connector	SMA female (FGR2-IOS-C-U) / TNC female (FGR2-IOS-CE-U)
Receiver	
Sensitivity	-108 dBm at 10^{-6} BER -110 dBm at 10^{-4} BER
Selectivity	20 dB at fc ± 115 kHz 60 dB at fc ± 145 kHz
System Gain	140 dB
Data Transmission	
Error Detection	32 bit CRC, retransmit on error
Link Throughput	115.2 Kbps
Data Interface	Serial
Protocol	RS-232/422/485, 300 baud – 115.2 Kbaud
Data Connector	10-pin header
Analog Inputs	
Number of Inputs	2
Accuracy, Resolution	± 0.1%, 16 bit
Input Range	0.2 – 5.62 V, 94 KΩ input resistance
Digital Inputs	
Number of Inputs	2
Input Pull-up	10 KΩ to 3.3 V
Input Pull-down	10 KΩ to GND
Input Connector	Mini Phoenix (3.55 mm)
Slave Input to Master Output Delay	1 sec. maximum
Signal Input Voltage Maximum	± 20 V
Maximum Count Size & Rate	32 bits, 1000 Hz
AI of DI Accuracy, Resolution	± 0.25%, 10 bit
AI of DI Input Range	0 – 3.5 V
Digital Output	
Number of Outputs	2
Current Rating	2 Amps maximum
Voltage Rating	Lesser of: 20 V or the radio supply voltage
Analog Output	
Number of Outputs	2
Accuracy, Resolution	AO1: ± 0.1%, 15 bit (Can act as 50 mA Sensor Power or DI) AO2: ± 0.1%, 16 bit
Output Range	4 – 22 mA
Internal Registers	
Battery/Supply Voltage	10 bits, 0 – 30 V, 1% Accuracy
Radio Temperature	1° C Units, -40° C to +70° C, 4° C Accuracy
Diagnostic Interface	
Connector	Separate 20-pin PCB header
Power Requirements	
Operating Voltage	6 to 30 V DC

Average Current Usage

Mode	6 V DC	12 V DC	20 V DC
Transmit	800 mA	380 mA	170 mA
Receive	90 mA	55 mA	40 mA
Idle	24 mA	16 mA	8 mA
Modbus Linked Lowpower=4	10 mA	7 mA	5 mA
WireReplacement Linked	30 mA	15 mA	8 Ma

General Information	
Operating Temperature Range	-40° C to +75° C
Dimensions	FGR2-IOS-C-U: 127 mm L x 62 mm W x 16 mm H FGR2-IOS-CE-U: 173 mm L x 96 mm W x 35 mm H
Weight	FGR2-IOS-C-U: 60 g FGR2-IOS-CE-U: 509 g
Humidity	0 to 95% non-condensing

FGR2-IO-IOE Specifications

Transceiver	
Frequency Range	902 – 928 Mhz
Output Power	5 mW to 1 W (+30 dBm)
Range, Line-of-sight	60 miles
Modulation	2 level GFSK
Occupied Bandwidth	230 kHz
Hopping Patterns	15, user selectable
Hopping Channels	50 to 112, user selectable
Hopping Bands	7, user selectable
RF Connector	SMA female (FGR2-IOS-C-U) / TNC female (FGR2-IOS-CE-U)
Receiver	
Sensitivity	-108 dBm at 10^{-6} BER -110 dBm at 10^{-4} BER
Selectivity	20 dB at fc ± 115 kHz 60 dB at fc ± 145 kHz
System Gain	140 dB
Data Transmission	
Error Detection	32 bit CRC, retransmit on error
Link Throughput	115.2 Kbps
Data Interface	Serial
Protocol	RS-232/422/485, 300 baud – 115.2 Kbaud
Data Connector	10-pin header
Analog Inputs	
Number of Inputs	2
Accuracy, Resolution	± 0.1%, 16 bit
Input Range	0.2 – 5.62 V, 94 KΩ input resistance
Digital Inputs	
Number of Inputs	2
Input Pull-up	10 KΩ to 3.3 V
Input Pull-down	10 KΩ to GND
Input Connector	Mini Phoenix (3.55 mm)
Slave Input to Master Output Delay	1 sec. maximum
Signal Input Voltage Maximum	± 20 V
Maximum Count Size & Rate	32 bits, 1000 Hz
AI of DI Accuracy, Resolution	± 0.25%, 10 bit
AI of DI Input Range	0 – 3.5 V
Digital Output	
Number of Outputs	2
Current Rating	2 Amps maximum
Voltage Rating	Lesser of: 20 V or the radio supply voltage
Analog Output	
Number of Outputs	2
Accuracy, Resolution	AO1: ± 0.1%, 15 bit (Can act as 50 mA Sensor Power or DI) AO2: ± 0.1%, 16 bit
Output Range	4 – 22 mA
Internal Registers	
Battery/Supply Voltage	10 bits, 0 – 30 V, 1% Accuracy
Radio Temperature	1° C Units, -40° C to +70° C, 4° C Accuracy
Diagnostic Interface	
Connector	Separate 20-pin PCB header
Power Requirements	
Operating Voltage	6 to 30 V DC
Average Current Usage	See table below

Mode	6 V DC	12 V DC	20 V DC
Transmit	800 mA	380 mA	170 mA
Receive	90 mA	55 mA	40 mA
Idle	24 mA	16 mA	8 mA
Modbus Linked Lowpower=4	10 mA	7 mA	5 mA
WireReplacement Linked	30 mA	15 mA	8 Ma

General Information	
Operating Temperature Range	-40° C to +75° C
Dimensions	181 mm L x 80 mm W x 38 mm H
Weight	163 g
Humidity	0 to 95% non-condensing

I2-IOS-C-U Specifications

Transceiver	
Frequency Range	2.4 – 2.483 GHz
Output Power	5 mW to 500 mW (+20 dBm)
Range, Line-of-sight	20 miles
Modulation	2 level GFSK
Occupied Bandwidth	230 kHz
Hopping Patterns	15, user selectable
Hopping Channels	50 to 112, user selectable
Hopping Bands	7, user selectable
RF Connector	SMA female
Receiver	
Sensitivity	-105 dBm at 10^{-6} BER -107 dBm at 10^{-4} BER
System Gain	134 dB
Data Transmission	
Error Detection	32 bit CRC, retransmit on error
Link Throughput	115.2 Kbps
Data Interface	Serial
Protocol	RS-232/422/485, 300 baud – 115.2 Kbaud
Data Connector	10-pin header
Analog Inputs	
Number of Inputs	2
Accuracy, Resolution	± 0.1%, 16 bit
Input Range	0.2 – 5.62 V, 94 KΩ input resistance
Digital Inputs	
Number of Inputs	2
Input Pull-up	10 KΩ to 3.3 V
Input Pull-down	10 KΩ to GND
Input Connector	Mini Phoenix (3.55 mm)
Slave Input to Master Output Delay	1 sec. maximum
Signal Input Voltage Maximum	± 20 V
Maximum Count Size & Rate	32 bits, 1000 Hz
AI of DI Accuracy, Resolution	± 0.25%, 10 bit
AI of DI Input Range	0 – 3.5 V
Digital Output	
Number of Outputs	2
Current Rating	2 Amps maximum
Voltage Rating	Lesser of: 20 V or the radio supply voltage
Analog Output	
Number of Outputs	2
Accuracy, Resolution	AO1: ± 0.1%, 15 bit (Can act as 50 mA Sensor Power or DI) AO2: ± 0.1%, 16 bit
Output Range	4 – 22 mA
Internal Registers	
Battery/Supply Voltage	10 bits, 0 – 30 V, 1% Accuracy
Radio Temperature	1° C Units, -40° C to +70° C, 4° C Accuracy
Diagnostic Interface	
Connector	Separate 20-pin PCB header
Power Requirements	
Operating Voltage	6 to 30 V DC
Average Current Usage	See table below

Mode	6 V DC	12 V DC	20 V DC
Transmit	375 mA	295 mA	140 mA
Receive	120 mA	80 mA	51 mA
Idle	9 mA	5 mA	3 mA
Modbus Linked Lowpower=4	10 mA	7 mA	5 mA
WireReplacement Linked	30 mA	15 mA	8 Ma

General Information	
Operating Temperature Range	-40° C to +75° C
Dimensions	127 mm L x 62 mm W x 16 mm H
Weight	58 g
Humidity	0 to 95% non-condensing